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An Analysis of Teacher's Judgements of Student's Executive Functions and Percieved Academic Competency Across Age Groups

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Dissertation Approval

This is to certify that the thesis presented to us by Evan Skolnik on the 31st day of May, 2016, in partial fulfillment of the requirements for the degree of Doctor of Psychology, has been examined and is acceptable in both scholarship and literary quality.

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Abstract

In the school setting, well-developed executive functions are associated with the metacognitive skills important for learning and are positively correlated with measures of student achievement across children and adolescents; however, development of executive skills has been shown to be inconsistent with chronological age among children. The current study examined if teachers' ratings of students' executive functions differ significantly among groups of students whose academic competence is judged to be above average, average, and below average and if these ratings differ significantly by age. Further, the study sought to determine if the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence would change based on student age. Participants included 254 teachers who provided ratings for a diverse sample of 813 students. Archival data consisted of student demographic information, McCloskey Executive Functions Scale (MEFS) teacher ratings of students' executive functions, and teachers' ratings of students' academic competence. Results provide evidence that executive functions differ significantly among different age groups of students and different groups of teacher-judged academic competency. No matter the age of the student, a consistent relationship emerged between teachers' judgments of academic competence and mean ratings of executive functions. Teachers' ratings of executive functions, overall, were highest for the oldest group of students and lowest for the youngest group of students. Teacher ratings of all executive functions were in the executive function strength range for students rated as having above-average academic competence, executive function deficit range for students rated as having below-average academic competence, and varied for students rated as having average competence.

Keywords: executive functions, human development, academic competence

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Chapter 1

Introduction

Statement of the Problem

The study of executive functions (EFs) is relevant because they relate to a host of everyday constructs in human functioning. In the school setting, EFs facilitate comprehending information, analyzing problems, recalling facts, drawing inferences, making judgments, thinking critically, and applying mental effort for extended periods of time (Levine, 1999). Older students are expected to listen to lectures that contain strings of long and varied sentences, as well as unfamiliar or technical vocabulary, while processing concepts and taking notes. They are also expected to work independently, to process information more metacognitively, and to exhibit greater self-regulation of behavior (Hartman, 2001; Levine, 1999). To be effective learners, students must know and utilize strategies at appropriate times, plan and monitor strategies, possess a healthy sense of motivation, maintain a belief that learning is a growing process, and be able to quickly and efficiently access previously learned information (Borkowski & Muthukrishna, 1992).

Because of the central role that EFs play in facilitating behavioral, cognitive, and emotional functioning, knowledge of EFs must increase and the quest to understand their relationship to academic outcomes must continue. This endeavor is increasingly important because students are expected to have the “self-responsibility” or “self-discipline” attributes that are a reflection of one’s effective use of executive capacities. Since students are typically judged by their demonstration of work they have produced and not by how or what they learned, students with EF deficits are likely to exhibit producing difficulties that result in poor achievement. Teachers may erroneously attribute students’ EF difficulties to “laziness, apathy, lack of willingness to take responsibility for their own actions, lack of motivation, overt hostility, or lack of respect for authority" (McCloskey, Perkins, & VanDiver, 2009, p. 138).

Not only are EFs and associated metacognitive skills important for learning, they also are positively correlated with measures of student achievement across children and adolescents (Best, Miller, & Naglieri, 2001; Blair & Razza, 2007; Sikora, Haley, Edwards, & Butler, 2002; Waber, Gerber, Turcios, Wagner, & Forbes, 2006). Although these standards aim for a normal or ideal performance from students, development of executive skills has been shown to be inconsistent with chronological age among children (Bayliss, Jarrold, Gunn, Baddeley, & Leigh, 2005; Lenroot & Giedd, 2006). Despite this fact, the school system expects all students of the same age to be functioning at the same level.

At present, retention is thought to be an obvious consequence for students who do not produce in the classroom. Often, these production deficits are caused by delays in development of EFs. While retention might seem to be a way to deal with EF maturational delays, research suggests otherwise. Jimerson's (2001) meta-analysis of retention found that 95% of the studies determined that students who were retained experienced either no benefit or a negative impact. Thus, a new approach to school failure that accounts for and remediates EF maturational delays may be needed. Stated more simply, targeting executive skills for intervention may be a better strategy than waiting an extra year for these pivotal skills to develop.

At present, research on the connection between a student's levels of executive skills and teachers' judgments about overall levels of achievement clearly shows a relationship between a student's executive skills and how he or she will perform on tests and classroom assignments. Bobick (2015) demonstrated that successful middle-school students are perceived as exhibiting very few EF difficulties while unsuccessful middle-school students are perceived as exhibiting many EF difficulties. To further the field's understanding of how EFs impact academic performance at all age levels, more research is needed that utilizes more models and methods of assessing EF across more student age groups. In addition, analyzing this type of data by each domain and each specific EF would also prove useful in shedding light on the connection between specific executive capacities and school achievement.

Purpose of the Study

The purpose of this study was to utilize the holarchical model of EFs to examine differences in teachers' perceptions of the EF capacities of students between the ages of 5 and 18 years. Students were grouped according to age and according to teachers' judgments about student academic competence to determine also if differences in teachers' perceptions of students' effective use of EFs are based on levels of academic competency and age.

Findings were compared to findings of similar studies that have not utilized the holarchical model in order to find important similarities and differences. Limitations, including the validity issues and confounding variables that impact the accuracy of teacher perceptions, were explored.

Research Questions

1. Do teachers' ratings of students' executive functions differ significantly among groups of different-aged students?

    1a. Does the relationship between teachers' ratings of executive functions and student age vary depending on the type of executive function being rated?

    1b. Does the relationship between teachers' ratings of executive functions and student age vary depending on the specific executive function being rated?

2. Do teachers' ratings of students' executive functions differ significantly among groups of students whose academic competence is judged to be above average, average, and below average?

2a. Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence vary depending on the type of executive function being rated?

2b. Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence vary depending on the specific executive function being rated?

3. Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence change based on student age?

Chapter 2

Review of Literature

The concept of executive functions (EFs) has captured the attention of researchers, practitioners, and onlookers in recent years. Although popular culture has attempted to simplify the definition of EFs, for example, Salus (2003) describing them as the brain's "CEO" or "control center," EFs, in fact, are not so easily operationalized (Denckla, 1999; Stuss & Alexander, 2000). Many clinicians are familiar with the Behavior Rating Inventory of Executive Function, which defines EF as "an umbrella construct that includes a collection of interrelated functions that are responsible for purposeful, goal-directed, problem-solving behavior" (Gioia, Isquith, Guy, & Kenworthy, 2000); however, this widely used definition is only one of many put forth by the research community. Despite fragmented identification of the various control processes, the term *EFs* is useful as "shorthand" for a group of mental constructs that "cue and direct" other mental constructs (McCloskey et al., 2009).

Theorists have attempted to describe EFs in a unitary manner. The construct has been referred to as a supervisory attentional system (Norman & Shallice, 1986), and "central executive" or coordinator of higher level information processing (Baddeley & Hitch, 1974). These types of definitions lead one to view EF at the top of the hierarchy of cognitive functions. However, such a conceptualization of EFs has not been demonstrated. These arguments have also attempted to encompass EFs as this type of single factor (e.g., Brown, 2006; Duncan, Emslie, Williams, Johnson, & Freer, 1996; Goldberg, 2001).

The general consensus tends to agree that EF is not a unitary construct but rather a group of many distinct control processes (Gioia, Isquith, Guy, & Kenworthy, 2000; McCloskey et al., 2009; Stuss & Alexander, 2000). While arguments otherwise do provide evidence that EF is a single mechanism, they are victims of a restrictive view of EF and the frontal lobes, the region of the brain most closely associated with the processing of EF. Broadly stated, the frontal region and associated connections carry out the executive processes. Observations of the frontal regions reveal structurally distinct organized functions (Goldman-Rakic, 2001). An adequate definition of EFs should convey that they are nonunitary and are not a general construct.

Neuroanatomical Underpinnings of EF

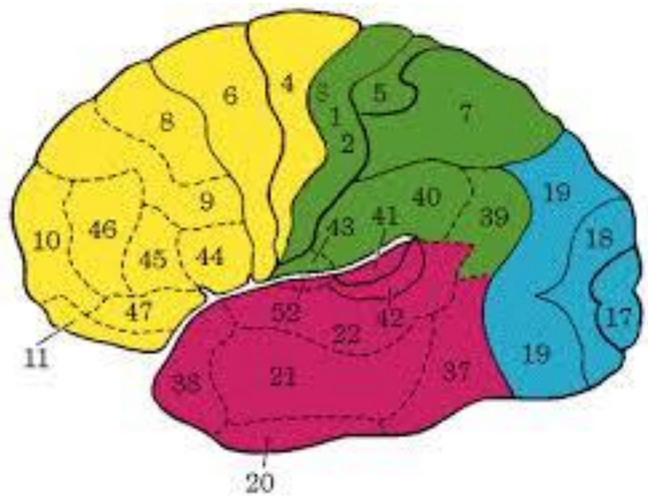
Study of the Frontal Lobe

The frontal lobe's connection toEF was discovered in the course of investigations of patients who experienced brain injuries to their frontal lobe and subsequent lobotomies in attempt to subdue associated symptoms (Brickner, 1936; Harlow, 1868; Wilkins, 1964). This research demonstrated significant changes to behavior and personality of the subjects involved. However, the behavioral, motor, and cognitive irregularities associated with frontal-lobe damage (Alexander & Stuss, 2000; Cummings, 1993) have been demonstrated in patients with nonfrontal and diffuse damage (Alvarez & Emory, 2006), suggesting that executive processes are intimately connected with regions outside of the frontal lobes. Connections exist between the frontal lobes and almost all regions of the brain, including the parietal, temporal, olfactory, and occipital sensory areas; associational cortices; and connections across hemispheres (Stuss & Knight, 2013).

Structure

The frontal lobes are located at the most anterior part of the brain, just above the sylvian fissure. They are divided into two symmetrical lobes and three major areas: the dorsolateral, medial, and basilar-orbital. With the aid of the Broadman area number system (Figure 1), the frontal lobe has been further subdivided. The primary motor region, known as the central gyrus, is located in Area 4. The premotor region is found in Area 6 and the posterior part of Area 8 (Stuss & Knight, 2013).

Figure 1. Broadman number system



The area of the frontal lobes that is most strongly associated with regulating EFs is the prefrontal cortex (PFC; Goldman & Rosvold, 1970; Stuss & Knight, 2013). This area constitutes roughly one third of the total volume of the cerebral cortex and is located in the frontmost part of the brain, directly behind the forehead. It encompasses Broadman Areas 8, 9, 10, 11, 44, 45, 46, and 47 (Stuss & Knight, 2013). The PFC is responsible for goal-directed, novel behavior. Conversely, well-established or automatic behavioral patterns are not processed within the PFC. The PFC connects with the other cortices of the brain, mediating the execution of complex actions associated with each particular connection. These complex connections are widely distributed and consist of units of memory, known as cognits, which temporarily store sequential sensory and motor information until the attainment of a goal and execute preparation for anticipated events (Stuss & Knight, 2013).

The prefrontal area can be broken down into the dorsolateral PFC, ventral PFC, frontal pole cortex, dorsal and medial prefrontal areas, anterior cingulate cortex, and orbitofrontal cortex. Stuss and colleagues have been postulated that different sections of the PFC specialize in distinctive, goal-directed behavioral functions (Stuss & Alexander, 2000; Stuss & Knight, 2013). While numerous theories on this specialization have been offered, new approaches in the future are needed to identify the definitive functions of each area (Aron, 2008). Despite a lack of understanding of the specialized roles of most of the prefrontal region, conceptualizations have been offered for the functioning of two areas, the dorsolateral and ventromedial regions (Wasserman, 2009).

The dorsolateral PFC, located on each outer side of the frontal lobe, is commonly associated with EFs because of its involvement in selective and sustained attention, visual/perceptual decision making, organization and strategy skills, maintenance of mental sets, shifting/switching mental sets, sequencing and holding sequences in memory, suppressing automatic responses, motor planning and motor execution, verbal and nonverbal fluency, and self-regulation. In addition, it may play a role in the integration of sensory-motor and mnemonic information (Wasserman, 2009). The ventromedial PFC controls emotion in novel decision making. It regulates affect and drive while evaluating risk and reward for potential outcomes (Bechara, Damasio, & Damasio, 2000). One way to distinguish the roles of the dorsolateral and ventromedial PFC is to think of “cold” or more cognitive functions as those regulated by the dorsolateral PFC, listed previously. Conversely, “hot” or more emotional capacities are regulated by the ventromedial cortex (O’Reilly, 2010).

The limbic region provides the drive with which the organism initiates actions toward an intended goal (Fuster, 2008). EF association with mood and motivation is evidenced by the frontal lobes' interconnection with the limbic systems in three areas: the cortical limbic lobe, the septo-hypothalamo-mesencephalic continuum, and the peripheral viseroendocrine (Stuss & Benson, 1984). Information that is deemed to be emotionally significant by the limbic structures associated with emotion, memory, and attention is managed synergistically between the limbic structures and anterior cingulate cortex. The salience of an emotional event can increase the level of attention that is recruited in a particular instance and the manner in which such an event is remembered. Dysfunction in the circuitry connecting these areas can result in a host of psychiatric disorders, particularly anxiety and posttraumatic stress, related to the storage and reexperience of emotional memories (Stuss & Knight, 2013).

Systems

EFs are output as part of a frontal-subcortical system, not the PFC exclusively (Barde & Thompson-Schill, 2002; Cummings, 1993; Rugg, Fletcher, Chua, & Dolan, 1999; Volz, Schubotz, & von Cramon, 2006). Seven general categories of frontal-subcortical circuits have been identified: skeletomotor, oculomotor, dorsolateral prefrontal, lateral orbitofrontal, medial orbitofrontal, anterior cingulate, and inferotemporal/posterior parietal (Middleton & Strick, 2000). These seven are an expansion of a former conceptualization in which only five circuits were identified (Alexander, DeLong, & Strick, 1986). In addition, improved imaging techniques also helped uncover a number of subcircuits within the identified seven circuits.

These circuits contain "open loops" branching to and from other cortical and subcortical structures. They also flow along direct and indirect pathways, which allow for activation and inhibition of structures within the brain (Wasserman, 2009). Each circuit involves a portion of the frontal lobe, projections to striatal regions, then to the globus pallidus and thalamus, and back to the frontal lobe (Alexander & Stuss, 2000). This system is "essential for the basic condition of all forms of conscious activity, mainly, the formation of plans and intentions that are stable enough to become dominant and to withstand any distracting or irrelevant stimulus" (Luria, 1973, p.198).

An attempt to conceptualize EFs by neurological bases was put forth by Wasserman's (2009) unpublished work. His review of studies analyzing prefrontal cortical neural circuitry identified five classes of self-regulatory loops: attention, evaluation, inhibition/initiation, output/optimization, and updating (or A-E-I-O-U, for short). Each group of loops encompasses more specific functions, and a number of functions can be executed at the same time. In general, the attention loops involve the direction of mental resources toward a particular point and maintenance of this focus in lieu of distractions. The evaluation loops refer to appraising situations for risks and rewards, potential goals, and strategies for achieving these goals. The inhibition/initiation loops specialize in stopping and starting actions. The ability to stop one thing and start another thing also can be thought of as shifting or switching. The output/optimization loop specializes in utilizing feedback to fine-tune or adjust behavioral functioning to maximize its efficiency. Lastly, the updating loop uses feedback as well, but does so by cueing this use of mental representations through the use of working memory.

Labeling EFs

Some of the earliest attempts to conceptualize the various roles of "the executive" (Baddeley & Hitch, 1974; Norman & Shallice, 1986) were somewhat limited in terms of the number of roles or constructs identified. Norman and Shallice (1986) were interested in the attentional system, particularly the recruitment of attention, the selection of what to attend to, and the function of sustaining attention. Baddeley and Hitch (1974) focused solely on the role of what they termed the "central executive" in the cueing of working memory.

More recent efforts have focused on a greater number of control functions in an attempt to derive a more specific definition. As a result, the literature on EFs has become diffuse. As recently as 2007, Jurado and Rosselli asserted the following:

> despite the frequency with which it is mentioned in the neuropsychological literature, the concept of EFs is one that still awaits a formal definition. Research efforts aimed at exploring the different aspects of this construct have often yielded contradictory evidence, resulting in a lack of clarity and even controversy regarding the true nature of executive abilities (p. 213).

In their review of the literature, Jurado and Rosselli (2007) identified that despite myriad different definitions, EFs are an essential part of human behavior because of their role in shifting mind set, inhibiting untimely behaviors, creating and initiating a plan, persevering, organizing one's thoughts, and engaging in moral and ethical behavior. They also found that despite suggestions that correlations demonstrate a relationship between EF and a single construct, psychometric and neurological evidence suggests that EFs are nonunitary. Through their study of development of EF across the lifespan, the authors found attentional control, planning, set shifting, and verbal fluency as correlating with the brain structure.

Several efforts have been made to conceptualize EFs based upon neuropsychological foundations (e.g., Fuster 1988; Luria, 1966). Pennington, Bennetto, McAleer, and Roberts (1996) sought to define EFs in terms of neuropsychological functioning. Their perspective is based on the fact that a variety of forms of neurological impairment (e.g., structural damage, neurochemical deficiencies and excesses, neurophysiological changes), as well as a variety of disorders, could lead to the same EF difficulties. To improve the discriminant validity of measures of executive impairments, they specified EFs as the following: inhibition, planning, and mental representation of tasks and goals. Utilizing measures that reflected these constructs could theoretically improve the discriminant validity problem.

There is difficulty identifying the EFs that are truly neurological in nature and those that are purely conceptual. Denckla (1999), who defined EF as delayed responding, future-oriented action selection and intentionality in the cognitive and emotional realms, also attempted to identify the executive "control processes." Denkla labeled them as initiating, sustaining, inhibiting, stopping, shifting, anticipating, planning, efficiency, and productivity. However, this brain-behavior model, Denkla warned, could be disconfirmed since research may fail to reveal regional sensitivity. Thus, a fully brain-based model of EFs will require a substantial amount of neurological and behavioral research in order to be confirmed. The difficulty of defining the role(s) of EF by specific subprocesses exists because of the problems involved in isolating, manipulating, and studying these subprocesses in experimental settings (Stuss & Alexander, 2000). The challenge of deriving an objective model or definition of EF has proved to be elusive.

A model of EFs based strictly on behavioral functioning was put forth by Hayes, Gifford, and Ruckstuhl (1996). They sought to identify "the actual behaviors people are speaking about with these terms" (p. 280). In contrast to the neurologically driven conceptualizations, Hayes et al.'s conceptualization offers a functionally driven understanding completely free of brain bases. Their conceptualization associates the behaviors of flexibility and verbal regulation with EF. These processes come online when immediate and commonly used sources of behavioral regulation are not available or effective in a given situation. In behavioral analytical terms, these processes mediate and alter the effect of a stimuli on a response and allow an individual to follow rule-governed behavior instead of situationally governed behavior.

Barkley (1997b) has focused on the role that EFs play in the focusing and sustaining of attention and the inhibition of impulsive responding, especially in terms of their disruption in the presence of attention deficit hyperactivity disorder (ADHD) symptomatology. Barkley's definition of ADHD focuses on an individual's deficits in behavioral inhibition, which he specifies to be (a) inhibition of the initial prepotent response (immediate reinforcement) to an event; (b) stopping of an ongoing response; and (c) preventing disruption of the previous two processes (interference control). The term inhibition is identified as essential to one's self-regulation in that "any response, or chain of responses, by the individual that serves to alter the probability of the individual's subsequent response to an event and, in so doing, functions to alter the probability of a later consequence related to that event" (Barkley, 1997, p. 68). EFs are referred to as one's private or cognitive form of self-regulation. Barkley defined four self-regulatory functions in his model: nonverbal working memory, verbal working memory, self-regulation of affect/motivation/arousal/, and reconstitution.

Lezak, Howieson, Lorring, Hannay, and Fischer (2004) have posited the following:

> the EFs can be conceptualized as having four components: (1) volition, (2) planning, (3) purposive action, and (4) effective performance. Each involves a distinctive set of activity-related behaviors. All of these functions are necessary in order to carry out appropriate, socially responsible, and self-serving adult conduct" (p. 611).

Volition is the process of determining what one wants and then creating some mental image of this destination. Planning is the process of generating the steps needed to achieve such a goal. Purposive action is the initiation, maintenance, switching, and stopping of behavior in a complex way in order to carry out a plan. Finally, effective performance is the monitoring, self-correcting, and regulating of these behaviors.

Arenas of EFs

Some researchers have identified self-regulatory EFs as not explicitly limited to the control of cognition but extending into other realms, such as the regulation of emotion (e.g., Christoff & Gabrieli, 2000; Eslinger, 1996; McCloskey et al., 2009; Royall et al., 2002). Borkowiski and Burke (1999) described EFs as implementations of higher level strategies across dissimilar settings and domains of expertise that cue or recruit an individual's awareness of a situation, choice and implementation of how to behave in a situation, and ability to determine if the chosen behavior remains appropriate for the situation.

In a review of definitions for EFs by the major researchers in the field, Eslinger (1996) identified self-regulation, sequencing of behavior, flexibility, response inhibition, planning, and organization of behavior as the most commonly referenced EFs. In order to include elements of each of these capacities identified in the research literature reviewed, Eslinger created the following definition: "Executive functions are defined as psychological processes that have the purpose of meeting a balance of immediate situational, short-term, and long-term future goals … [and] that span physical-environmental, cognitive, behavioral, emotional, and social spheres" (p. 381). In addition to highlighting EF arenas, this definition of EF is a more strongly worded, all-encompassing definition in comparison to the others discussed in this literature review.

The idea of EFs being unique across various spheres or settings has been explored within neurobiology. Through a review of brain-imaging literature, Christoff and Gabrieli (2000) demonstrated that the dorsolateral PFC is utilized when information from the external world is being evaluated. However, the frontopolar cortex is also recruited for information from the internal world, or self-generated information. Therefore, frontal activation varies based on the type and context of task. EFs within the internal or intrapersonal realm are thus distinct from EFs within the external realm.

Along similar lines of thought, McCloskey et al. (2009) identified four separate domains within which EFs appear to operate in a dissociable manner. They labeled these as *arenas of involvement* and specified them as the *intrapersonal arena* (control of self), the *interpersonal arena* (control of self in relation to others), the *environment arena* (control of self in relation to the environment), and the *symbol system arena* (control of self in relation to man-made communication processes, including reading, writing, and mathematics).

Hierarchy of EFs

In addition to discussing EFs across various spheres of activity, conceptualizations have included more long-term and abstract roles that EFs play (Christoff & Gabrieli, 2000; Eslinger, 1996; Royall et al., 2002; Welsh & Pennington, 1988). Royall et al. (2002, p.378) specified, "higher cognitive functions such as insight, will, abstraction, and judgment," as being dependent on the frontal lobes." Being aware of these more complex constructs, Stuss and Alexander (2000) put forth a hierarchical model of EF, incorporating self-awareness at the highest and most complex tier. They discuss four levels; *arousal-attention; perceptual-motor; executive mediation; self-awareness*. Each level connects to high and lower levels as a way to facilitate and digest analyses and operations as they flow up the levels. The highest levels are located in the frontal lobe and are responsible for action planning, inhibition and facilitation of cortex activity, working memory, activity with basal ganglia and to allow for the carrying out and learning of plans. The researchers describe self-awareness as emerging “from convergence of emotional states and memory - not simply explicit remote memory of experience or explicit semantic knowledge - but memory of abstract mental states that allow construction of expectancy and thus memory for the future. Human consciousness is an unstable template of experience and emotion (p.295)”. Self-awareness therefore represents a very personal process, involved in cueing and analyzing abstract models of one’s own experience.

Mikaye et al. (2000) investigated relationships among EFs. In their analysis of three commonly referenced EFs (i.e., shifting, inhibiting, and updating), they found moderate correlations. Thus, despite the distinctiveness of individual functions, they often work in tandem and have potential to be conceptualized as a group. Stuss and Benson’s (1986) comprehensive behavioral/anatomical model of EFs conceptualized frontal-lobe functioning as hierarchical and increasingly more abstract in nature. Thus, a comprehensive model of EF processes would be expected to group EFs by level of complexity and by which functions load with each other.

Holarchical Model

McCloskey et al. (2009) proposed a holarchical model in which cognition performs many different EFs that operate across four discrete arenas of involvement: intrapersonal, interpersonal, environment, and symbol system. The model also organizes EFs into various tiers. However, each individual possesses his or her own unique and fluid development of functions within each tier, which means the development of functions within a higher tier is not necessarily contingent on the full development of the functions within lower tiers. At the lowest tier, the Self-

Regulation level consists of processes that cue the use of other mental capacities to direct and control perceptions, thoughts, actions, and emotions.

This tier overlaps with many contemporary models of EF and has some similarity to Barkley's (1997a) definition of self-regulation. The holarchical model, however, identifies numerous self-regulatory EFs and organizes them in unique clusters. The model originally specified 23 self-regulation EFs (McCloskey et al., 2009). The number of self-regulation EFs was later expanded to 33 (McCloskey & Perkins, 2012). The clusters are labeled Attention, Engagement, Optimization, Efficiency, Memory, Inquiry, and Solution. These clusters are somewhat similar to the A-E-I-O-U loops (Wasserman, 2009) discussed earlier in that they are based on the neuropsychological literature that defines different frontal-lobe circuits. These clusters contain some of the 33 self-regulation EFs mentioned earlier. The Attention cluster is comprised of the ability to cue awareness to the external environment (Perceive/Aware), cue attention to relevant stimuli (Focus/Select), and cue sustained engagement in a process (Sustain). The Engagement cluster involves cueing the start of task performance (Initiate), putting adequate effort into performing a task (Energize), inhibiting impulsive responding (Inhibit), stopping ongoing activity (Stop), pausing momentarily before returning to ongoing activity (Interrupt), becoming open to the need to change (Flexible), and moving from one thing to another (Shift). The Optimization cluster involves cueing of the adjusting of intensity of perception, feeling, thought, and action (Modulate); the monitoring of perceptions, feelings, thoughts, and actions (Monitor); the correction of errors (Correct); and the integration and balancing of opposites (Balance). The Inquiry cluster comprises the capacity to cue the process that determines what it will take to accomplish a task (Gauge), looking ahead (Anticipate/Foresee), estimating time (Estimate Time), analyzing the details of a situation or problem (Analyze) and evaluating and comparing possible solutions or work products (Evaluate/Compare). The Efficiency cluster involves the cueing of sensing the passage of time (Sense Time), adjusting work pace (Pace), sequencing of elements (Sequence), and executing well-rehearsed routines (Using Routines). The Memory cluster involves the cueing of the holding of information for a brief time (Hold), the manipulation of information in working memory (Manipulate), the storage of information (Store), and the retrieval of information (Retrieve). The Solution cluster involves the cueing of the generation of novel solutions to problems (Generate), associative problem solving (Associate), planning (Plan), organizing (Organize), decision making (Decide), and prioritizing (Prioritize).

McCloskey et al. (2009) saw each self-regulation level of EF as being connected via a neural pathway to one another, as well as regions responsible for separate broad domains of functioning, including perception, emotion, cognition, and action. Cueing and coordinating the use of various mental constructs requires a high level of collaboration among self-regulation EFs, which explains the conceptualization of EFs as a set of section leaders, or coconductors, rather than as a single conductor of the orchestra.

As the model advances to higher levels, the executive processes become more abstract. One must remember, however, that mastery of all skills at lower tiers is not required for the development of functions at higher tiers. The next tier is occupied by Self-Realization and Self-Determination. Self-Realization is an individual's ability to be aware of him orherself and others, to reflect on the past, and to be aware of the various executive capacities he or she is bringing online, while Self-Determination,is an individual's ability to set goals and plan for the future and engage in long-term planning. The next level, Self-Generation, allows an individual to cultivate a philosophy of life as he or she questions his or her existence and purpose. The highest and most abstract tier, Trans-Self- Integration, is defined as an individual's ability to experience a unified state of consciousness, or the ability to see beyond the autonomous self (McCloskey & Perkins, 2012). Overall, this model effectively incorporates the theoretical and neurostructural knowledge available on EFs.

Development of EFs

Developmental Trajectory

Since the executive processes reflect various, separate neural and cognitive constructs, there is no assurance that all executive capacities within an individual will develop evenly (McCloskey et al., 2009). However, in general, as the frontal-lobe brain areas develop from early childhood through early adulthood, their growth and differentiation mirror the development and refinement of an individual's EFs (Levin, Culhane, Hartmann, Evankovich, Mattson, Harward,1991; Welsch, Pennington, & Groisser, 1991).

At birth, the basic connections of the frontal lobe are developed (Stuss, 1992). Welsh and Pennington (1988) theorized that the "rudiments of frontal functioning are present early in development and have a protracted course of development" (p. 202). The reach of an 11- to 12-month-old infant to grasp an object requires a goal-directed mental set in which certain behaviors are inhibited while others are strategically planned to execute the grasping behavior (Welsh & Pennington, 1988). From these early signs of executive control, the structure and function of the PFC undergoes major changes during the preschool stage (Epsy, Kaufmann, Glisky, & McDiarmid, 2001). Stuss (1992) has offered that the development of frontal functions is dependent not solely on anatomical growth, but also on the increasing task demands of other regions of the brain. The systems involved in learning, memory, emotion, cognition, language, and attention develop well into life (Romine & Reynolds, 2005).

Romine and Reynolds' (2005) review of research also pointed to types of EFs that develop during different stages. For instance, between the ages of 5 to 8 years, children demonstrate concept formation, set shifting, and rudimentary planning skills. During this time, a huge increase in problem solving, planning, fluency, and inhibition of perseveration occurs. A critical period for development of cognitive flexibility, goal setting, and information-processing efficiency occurs between 7 and 9 years of age (Anderson, 2002). A major increase in all areas is observed during the ages of 8 to 11 years. While most EFs are relatively mature by this time (Anderson, 2002; Romine & Reynolds, 2005), several functions, such as planning and verbal fluency, continue improving through adolescence and into adulthood (Romine & Reynolds, 2005).

In their review of the literature on frontal-lobe development, Romine and Reynolds (2005) were able to determine general developmental stages for frontal-lobe functioning. In a review of the research from 1984 to 2004, they determined that medium to large increases in frontal-lobe performance occur between the ages of 5 and 8 years and from 8 to 11 years. Smaller increases were identified in the 11- to 14-year age range. From the ages of 14 to 17 years, a range was observed, from no change to medium change. Finally, in adulthood, a range from no age-related increases in EF performance to large increases was possible (Romine & Reynolds, 2005). McCloskey et al. (2009) theorized that self-determination and self-realization can vary in their development, developing as early as prior to adolescence but generally not until the adolescent period. They suggested that self-generation and trans-self-integration typically do not emerge until early adulthood and may not even develop at all.

Intraindividual Developmental Discrepancies

Although research has revealed a developmental course for EFs (Bayliss et al., 2005; Lenroot & Geidd, 2006), the trajectory of EF development can vary by specific individual. Lenroot and Giedd (2006) utilized magnetic resonance imaging of frontal, cortical, and subcortical areas to demonstrate observable structural and synaptic overlaps among individuals in the same gender group, age group, and mental-health group. Despite this clear grouping, high variation was observed among the individuals in the study. In the context of the classroom, this variation means that the EF of students can vary between all students and particularly between genders, among birth months, and whether an individual has experienced a psychiatric condition.

One condition that relates particularly to EF is ADHD. EF has been described as playing a central role in ADHD (Barkley, 1997b). Prevalence rates now estimate that as many as 7.1% of children are diagnosed with ADHD worldwide. Neuroimaging has found smaller frontal-lobe volumes, located mostly on the right (Castellanos et al., 1996) as well as lower frontal activation (Krain & Castellanos, 2006; Rubia, Smith, Taylor, & Brammer, 2007). Developmental syndromes like ADHD can contribute to an approximate 30% chronological delay in the development of EFs (Shaw et al., 2007).

The discrepancy in development of EFs has important implications. For instance, Bayliss et al. (2005) found that working memory (a process that, if not an EF itself, is heavily dependent on executive control) is a crucial element of higher level cognition and is thus a core factor for student achievement in school. While Gathercole, Pickering, Ambridge, and Wearing (2004) identified a linear path of development for working memory, beginning in early childhood through adolescence, Bayliss et al. (2005) found considerable age-related variations in the underlying components of working memory: processing speed, storage capacity, and controlled attention capacity. This finding suggests that, in the context of schools, the expectations for increasing self-regulation of learning and academic production throughout students' school careers do mirror a general trend of growth in most children; however, variation in the EF competency of students should be expected.

EF's Relationship with Academic Achievement

Relationship with Performance of Standardized Assessments

Despite an apparent lack of recognition by the educational system, academic achievement and EFs do have a strong relationship (Best et al., 2011; Blair & Razza, 2007; Sikora et al., 2002; Waber et al., 2006). This idea was well demonstrated by Best et al. (2011) in a wide-ranging study that found a correlation between complex EF tasks (as measured by the Cognitive Assessment System planning tasks) with achievement tasks (as measured by the Woodcock Johnson Tests of Achievement). Their findings showed that performance on planning, self-monitoring, and self-correcting tasks each had a similar relationship with both math and reading performance. Based on this pattern, the researchers suggest a domain-general view on the relationship between academic achievement and EF.

In contrast to these findings, Waber et al. (2006) suggested a difference in achievement outcomes depending on variation within one's EFs. The study analyzed the relationship between students' EFs and their performance on standardized tests. The study's sample consisted of fifth-grade school students from low-income, urban neighborhoods. EFs were measured by neuropsychological assessments, as well as by teacher ratings of students' executive and behavioral functioning. The children who performed poorly on standardized tests also performed poorly on teachers' metacognitive ratings, but did not perform poorly on neuropsychological measures of EFs. Thus, while EFs relate to academic achievement, this evidence suggests that diverse functions may affect achievement outcomes differently.

Relationship with Learning

These findings suggest that EFs may play a significant role in facilitating student learning. Borkowski and Muthukrishna's (1992) list of behaviors that sophisticated learners possess supports this idea by illustrating the relationship between EFs and academic production. Key examples of these behaviors are learners knowing and utilizing strategies at appropriate times, planning and monitoring strategies, possessing a healthy sense of motivation and a growth mindset, and being able to quickly and efficiently access previously learned information. Learners who do not obtain and refine these skills over time are likely to encounter learning difficulties.

Given the role of EFs in human cognition and the observed intraindividual differences in EF development, occurring mainly from childhood through young adulthood, the role of EFs in school performance must be examined closely. A body of evidence demonstrates that EFs are intertwined with the processes of math, reading, and writing (Berninger & Richards, 2002; Kaufman, 2010; McCloskey et al., 2009), arguably the three most important academic skills in modern education. While more higher order executive skills may play a role in facilitating student performance on state assessments, Monette, Bigras, and Guay (2011) demonstrated how moment-to-moment executive skills may be associated with math and reading/writing skills competence.

Relationship with Reading

Reading is typically characterized by phonological and orthographic processing, oral-motor functioning, sight-word recognition, decoding, speed and fluency, comprehension and language skills, verbal reasoning, and application of previously learned information (McCloskey et al., 2009). In addition to these skills, EFs are closely involved in one's reading competency.

Berninger and Richards (2002) stated that "during text reading, the executive system manages online links between the reading lexicon and (a) the incoming stimuli and existing representations of the visual system, (b) the existing representations in the aural/oral language systems, (c) the cognitive system for reasoning" (p. 160).

Kaufman (2010) discussed EF as a key "non-linguistic" factor in reading. Individuals with executive deficits may experience reading difficulties even with no neurologically based dyslexia. The ability to sustain attention, for instance, allows for the sufficient focus on letter-sound associations that need to be learned and called upon during word reading. This ability to sustain attention also facilitates the highly visual, rapid automatic naming processes that allow for fluent letter sound and sight word identification. The ability to monitor oneself during the reading process keeps individuals from guessing on words based on first letter. Effective decoding and word recognition are dependent on focused attention, accurate perception of words, inhibition of incorrect word naming, retrieval of previously learned information, self-monitoring, and self-correcting. Executive skills help a reader sustain reading in a left-to-right manner, prevent the skipping of lines, and keep track on the page (Kaufman, 2010; McCloskey et al., 2009).

The ability to shift can facilitate moving from word reading to comprehending the material just read. In addition to facilitating the process of reading, EFs are heavily involved in comprehension (Kaufman, 2010; McCloskey et al., 2009; Locascio, Mahone, Eason, & Cutting, 2010; Sesma, Mahone, Levine, Eason, & Cutting, 2009). In addition to the functions needed for fluent reading, to read for fluency and comprehension, a reader must utilize all of the self-regulation processes involved in fluent reading, as well as initiating, sustaining, holding, and manipulating the incoming information in working memory and multitasking everything through the cueing of sustained effort, organization, planning ahead, balancing, pacing, monitoring, and correcting (McCloskey et al., 2009).

Sesma et al. (2009) examined the potential cause of reading deficits in students who did not exhibit word-reading problems. They found that a significant proportion of reading comprehension was related to working memory and planning. Therefore, a structured approach to reading and keeping the capacities of holding and manipulating information in mind are important facilitators of reading comprehension. Conversely, these capacities have very little to do with word reading. Locascio et al. (2010) did find that individuals with word-reading problems and phonological processing difficulties experience deficits in verbal working memory and response inhibition. The word-reading deficits in these individuals, however, were found to be caused by the phonological issues and not the executive issues. Consistent with the finding from Sesma et al. (2009), strategic planning was found to be a significant contributor to reading comprehension.

Relationship with Writing

Writing is another core skill that is strongly reliant on EFs (Beninger & Richards, 2002; Graham, Harris, & Olinghouse, 2007; Kaufman (2010); McCloskey et al., 2009). Berninger and Richards (2002) detailed the roles of EFs as creating goals and plans, updating and monitoring, reviewing and revisiting, coordinating multiple jobs, coordinating cross talk with other systems, supervising working memory, and guiding reflections. In addition, Kaufman (2010) argued that the generation of output is one of the core components of the writing process, since initiating and sustaining both cognitive and motor output are essential to writing.

Self-regulation is involved in planning and organizing, producing text, following punctuation rules, shifting through stages of the writing process (prewriting, writing, and revision), utilizing strategies, and persevering when a writing task is highly demanding (Kaufman, 2010). McCloskey et al. (2009) examined writing as a multi-process behavior, involving the directing of specific cognitive processes related to text formation and transcription, text production, spelling, and content generation. Similar to the reading process, cueing of these self-regulatory processes must be multitasked. The mastery of these processes and ability to gauge, organize, forsee/plan, balance, shift, monitor, and correct these processes facilitate higher level writing (text generation and text editing/revision). Because written expression also requires reading and a great group of processes must be cued and directed, written expression requires the use of many executive processes.

In the larger school context, writing is central to the ability of students to write notes during class. Altemeier, Jones, Abbott, and Berninger (2006) conducted an analysis to determine which executive skills were involved in note taking, specifically copying from the board and using those notes to write a report. They found that inhibition played a strong role in the note-taking process and verbal fluency was strongly related to the ability to compose a written report. Thus, the process of writing information that has been provided requires much less executive involvement than writing original or self-generated content.

Relationship with Math

Mathematics involves the translation and encoding of information across the quantitative, visual, motor, verbal, and image representation realms. It is arguably the most complex academic skill and requires the use of executive skills to conduct the various systems needed to compute solutions to complex problems. While some math is automatized, an array of executive processes is needed to cue and direct the various systems involved in math computation. However, the more automatized a person's basic math automaticity, the more executive capacity that person will have to utilize for the strategic/problem-solving components of math and processing (Berninger & Richards, 2002).

According to Blair and Razza (2007), "the problem solving process requires the individual to represent information in working memory, to shift attention appropriately between problem elements, and to inhibit the tendency to respond to only the most salient or most recent aspect of a given problem" (pp. 658-659). In addition, completing math problems is strongly dependent on strategy selection and execution. While some math problems can be presented in a straightforward fashion, some problems, such as word problems, require a student to figure out the correct strategy or operation before computation can be applied. This process of problem review, strategy identification, and strategy application requires a considerable amount of self-regulation and direction (Kaufman, 2010).

From a simpler perspective, executive control is needed for purposeful attention to make sure words are read properly, signs are not misread, place values are aligned, and decimals are in the correct place. Self-monitoring is needed for checking work, avoiding careless errors, and maintaining a consistent performance between math assignments. Shifting and cognitive flexibility is required to go from one step (e.g., setting up the problem) to the next (e.g., solving the problem), moving from one algorithm type (e.g., addition) to the next (e.g., subtraction), and trying a different strategy if another is not effective (Kaufman, 2010). Depending on the type of math problem, EFs are needed to call upon specific cognitive processes, abilities, and lexicons. Cueing may be needed to retrieve information, initiate and maintain focus, monitor, and inhibit (McCloskey et al., 2009).

The ability to inhibit impulsive responding, to shift sets, and to self-monitor was found to be integral to obtaining early math skills (Blair & Razza, 2007; Clark, Pritchard, & Woodard, 2010). Bull and Scerif (2001) demonstrated that children of lower mathematical ability had difficulties directing the use of working memory and performing tasks that measure the ability to inhibit both distracting information and previously learned information. Upon closer inspection, they noticed many of these children did not show an overall delay in “the central executive” but did show normal functioning for some EFs and deficient functioning for others. They concluded that students may do poorly in math as a result of overuse of one EF, such as activating relevant prior knowledge combined with an inability to suppress irrelevant prior knowledge.

EF Improvement in the Academic Setting

Dweck’s growth mindset (2010) and McCloskey et al.’s (2009) holarchical model view EF as progressing at varying rates within and across individuals. In an article titled, “Even Geniuses Work Hard,” Dweck (2010) considered the concept of “growth mindset.” This approach applies to individuals who “believe that they can develop their intelligence over time” (Dweck, 2010, p. 1), as opposed to it being a fixed trait. The promotion of the growth mindset could lead to intervention efforts to improve students’ use of EF. A fixed mindset suggests that EF difficulties cannot be changed.

While some general developmental trends can be observed, development of EF within an individual clearly can vary, depending on one’s experience. Teachers may use this knowledge to differentiate expectations for students regarding different EF competencies, while working to teach executive skills to students lagging behind. Research and efficacious practice show that executive skills can be taught to individuals of varying ages and ability levels. Several arguments have been put forth that support that explicitly teaching children executive skills could improve their academic performance (e.g., Case & Harris, 1992; Marlow, 2000; Meichenbaum & Goodman, 1971; Reid & Borkowski, 1987).

Meichenbaum and Goodman (1971) investigated whether or not cognitive self-instructional training could reduce impulsivity in school children. This training, which taught students to verbalize to themselves questions about the demands of a given task, answers to these questions, self-guidance instructions to perform the task, and self-reinforcement, was shown to significantly improve impulsivity. Simply having an adult model this behavior appeared to improve performance somewhat as well.

Reid and Borkowski (1987) analyzed whether a cognitive instructional program focusing on strategy instruction, self-control, and attributional retraining could improve these skills in students who were lacking them (specifically students who were hyperactive and learning disabled). Results indicated that short-term effects (approximately 10 months) were observed for children who received training in all three components (experimental group) as opposed to children who received strategy training alone (control group). The children in the experimental group demonstrated increased success in strategy-based learning, improved attributional beliefs, and greater self-control. This study demonstrated the importance of metacognitive skills, such as self-knowledge and self-efficacy, as contributors to an individual's use of strategies. As Dweck (2010) suggested, the mindset of an individual is an integral factor in whether that individual experiences improvements in functioning.

Explicit teaching of executive skills has shown to improve students' functioning on specific academic skills as well. Kurtz and Borkowski (1987) demonstrated that an executive instruction program emphasizing strategy use, self-monitoring, and self-evaluation could improve reading comprehension in impulsive children. Case and Harris (1992) showed how instruction in self-regulated strategy use could reduce the number of operational errors that students made on math problems. Studies like these provide evidence that EFs not only are important to academic success, but when they are explicitly targeted for improvement, also can improve academic performance.

Teachers' Perceptions of Academic Competence - Learning vs. Producing Difficulty

From the information presented on the relationship between EF and academic performance, one could ask, "Is this relationship understood and capitalized on in today's schools?" McCloskey & Perkins (2012) offered the opinion that schools are biased toward underappreciating the importance of EF in school-aged children. Despite a well-known unevenness in the development of executive skills among developing children, school students are held up to the same standard. Students are expected to have "self-responsibility" or to be "self-disciplined."

McCloskey et al. (2009) highlighted the key distinction between learning difficulties and producing difficulties. While a learning disability could be characterized as the disruption of basic processes such that initial perceptions are not adequately prepared for mental representation, a producing disability involves a students' forming inadequate responses to questions, failing tests, or doing poor work, even if learning has taken place. Since students are typically judged on how effectively they demonstrate what they have learned (passing tests, completing assignments and projects) rather than on what they have learned and how they have learned it, students who demonstrate producing difficulties will often be judged as having learning difficulties.

Students with learning difficulties and producing difficulties typically will be identified relatively quickly, but only their learning disability will be acknowledged, even though their producing difficulties clearly had them referred in the first place. That is, their lack of production will be attributed to their learning disability. Executive deficits often will go unnoticed and not identified as a contributing factor to these students' poor performance. Well-developed EFs can serve as protective factors for students with learning difficulties, enabling them to find ways to produce adequately by developing compensatory strategies. Unfortunately, these students do not stand out as struggling because they are findings ways to produce; consequently, identifying these students as having a learning disability could take longer than necessary. McCloskey et al. (2009) identified an even larger problem, however: Students who have producing difficulties but no identifiable learning disability or medical condition will not receive the specialized support they may need. These students often are referred at early ages because of their lack of adequate production. Assessment results, however, are not indicative of any learning disability that would be considered the source of their lack of production. Many times, they score high on both intelligence and achievement tests. Consequently, these students may be labeled with "character deficiencies such as laziness, apathy, unwilling to take responsibility for their own actions, lack of motivation, overt hostility, or lack of respect for authority" (p. 41). This misconception leads one to conclude that better education about, measurement of, and treatment for executive deficits are needed in today's schools.

Assessment of EFs

EFs can be assessed in a variety of ways. The first of these are indirect informal methods, which offer the greatest level of flexibility. Informal methods consist of interviewing parents and teachers and reviewing student records; however, these methods should not be used as the sole means of data collection for an EF assessment. The next method is indirect formal. This method utilizes standardized rating scales, which offer more objective data than an informal method can provide. Direct informal methods are a third option and typically involve the use of student observation or interview. Finally, direct formal methods involve an interaction with the subject. The performance can be both directly observed and quantitatively measured. Given the importance of understanding the executive profiles of school students, McCloskey et al. (2009) argued that many current assessment instruments give very little information on using their results for the planning and implementation of interventions for students who perform poorly. Nonetheless, a number of instruments have been developed to assess EFs. They are becoming increasingly more commonplace in everyday psychological practice.

The indirect formal behavioral rating scales are most commonly used to assess EFs in school settings. Examples of behavioral rating scales include the Behavioral Assessment of the Dysexecutive Syndrome (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), the Frontal Systems Behavior Scale (Grace & Malloy, 2000); and the Comprehensive Executive Function Inventory (Naglieri & Goldstein, 2012). One of the most widely used rating scales in schools is the Behavior Rating Inventory of Executive Function (BRIEF), created by Gioia, Isquith, and Guy (2000). This rating scale has two forms that measure EF behaviors that are manifested at the home and school settings. Teachers and parents provide endorsements that load on eight clinical scales, including Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor.

In terms of clinical applications, McAuley and team observed that the BRIEF tended to be a good predictor of ADHD, but because children with only behavioral concerns and not ADHD also tended to score high on the BRIEF, the tool may not be the best diagnostic instrument when used in isolation. In addition to being strongly correlated with behavioral symptoms, the BRIEF also showed a good association with academic skills, with metacognitive and behavioral regulatory components showing their own unique associations with specific academic skills (McAuley, Chen, Goos, Schachar, & Crosbie, 2010). This finding highlights that rating scales such as the BRIEF, with their ease of usability, are effective tools for clinicians.

Direct formal behavioral assessments have good applications as well. Neuropsychological tests are especially useful in assessing different aspects of EFs While rating scales are designed to assess a broad range of EFs, neuropsychological tests typically assess a single EF. Some of these assessments are the Wisconsin Card Sorting Test (Heaton, Chelune, Talley, Kay, & Curtiss, 1993), the NEPSY: A Developmental Neuropsychological Assessment (Korkman, Kirk, & Kemp, 1998), and the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). The D-KEFS is one of the more widely used direct formal assessments of EF. This assessment consists of a set of nationally normed tests that directly assesses EFs in children and adults. The D-KEFS can be administered as a battery of tests to provide a comprehensive assessment of a diverse set of EFs or each of the nine unique subtests can be administered in isolation or in combination to meet the specific concerns of a particular assessment.

The various subtests of the D-KEFS demonstrate a flexible and varied direct assessment of EFs. The Trail Making Test assesses cognitive shifting on a visual-motor task. It also assesses various skills related to task switching (i.e., visual scanning, number sequencing, letter sequencing, and motor speed). The Verbal Fluency Test assesses verbal fluency and cognitive flexibility. The Design Fluency Test measures initiation of problem-solving behavior, visual fluency, inhibition in drawing previous designs, monitoring performance, and cognitive shifting. The Color-Word Interference test assesses verbal inhibition and cognitive flexibility. The Sorting Test assesses initiation of problem-solving behavior, verbal and nonverbal concept formation skills, the ability to describe sorting rules, and the ability to inhibit previous responses in order to think and behave flexibly. The Twenty Questions Test examines problem solving through the use of feedback and flexible abstract thinking in generating yes/no questions. The Word Context Test measures deductive reasoning and flexibility in thinking. The Tower Test assesses for spatial planning, rule learning, inhibition of impulsive responding, and establishing and maintaining the cognitive set of the task. Finally, the Proverb Test assesses the ability to formulate meaning from a concrete phrase, tapping verbal fluency in generating abstract thinking.

Banich (2009) argued that the very nature of EFs makes measure difficult. Since EFs refer to a wide domain of skills, “there is no single agreed-upon gold standard test of executive function. Rather, different tasks are typically used to assess its different facets” (Banich, 2009, p. 89). Significant relationships between rating scales and direct assessments of EF have not been observed (McAuley et al., 2010). Thus, while such scales as the BRIEF may serve as powerful clinical tools, they may not assess EFs to the extent that they are believed to. A likely explanation is that rating scales, such as the BRIEF, and direct assessments may be measuring two different and distinct aspects of EF, one cognitive and one behavioral (McAuley et al., 2010). The major critique McCloskey et al. (2009) presented in regard to most current assessments of EF is that these instruments are limited to measurement within only one arena. The foremost neuropsychological assessments, for example, measure EFs only within the symbol system arena and thus should not be used to make assumptions about an individual’s functioning in the intrapersonal, interpersonal, or environment arenas. Thus, current assessments can lead to an overgeneralization of results and neglect the fact that EFs are not a unitary construct.

Considering this idea, practitioners utilizing EF assessment tools must consider the domain of EF they want to assess before they consider the construct or factor to measure. For instance, if a student has trouble following directions, a rating scale for working memory may be useful. However, if the student is having trouble with complex reasoning, a direct assessment may be more relevant. McCloskey et al. (2009) have laid out a set of qualities that an EF assessment should have. First, it should not set out to answer if a person has "executive dysfunction." Instead, it should "clearly identify problems and concerns, specify existing strengths and weaknesses, and lead to specific interventions that draw on strengths while addressing specific problems and concerns" (p. 97). The authors also provided a definition of a *process-oriented approach.* This construct is the process of carefully observing how a person performs the assessment task. This observation and subsequent interpretation can be done with any measure of cognitive, academic, or behavioral functioning. The emphasis is on analyzing how the child performs instead of on a quantitative outcome.

While this approach is beneficial because it allows an examiner to obtain data that may not otherwise be captured by the means previously discussed, analyzing how a child performs requires expertise on the part of the clinician to adequately understand the functions being observed. In addition, there is no guarantee that the function of interest will be observed (McCloskey et al., 2009). Ideally, an EF assessment should utilize the best combination of this approach and direct formal, indirect formal, and indirect informal approaches to adequately identify an individual's executive strengths and weaknesses and to identify intervention approaches to provide greatest improvement.

Summary of Literature Review

The concept of EFs has grown increasingly popular. EFs can be described as mental constructs that cue and direct other mental constructs. The general consensus is that EF is not a unitary construct, but rather a group of many distinct processes. The frontal region and associated connections carry out the executive processes. There are connections between the frontal lobes and almost all regions of the brain. The PFC, located at the most anterior part of the frontal lobe, is responsible for goal-directed, novel behavior. EFs are output as part of a frontal-subcortical system, not the PFC exclusively. Seven general categories of frontal-subcortical circuits have been identified.

While defining the role(s) of EF particularly by specific neurological processes is difficult, there are several modern-day conceptualizations of EF. A variety of researchers have attempted to narrow the definition to the specific cognitive control processes. Others have kept their definitions more behavioral in nature. Some have articulated multiple domains and/or arenas within which EFs operate. Another approach has been to organize EF by level of complexity, from most straightforward to the most abstract. Taking into consideration numerous conceptualizations, EFs can be defined as mental processes that manage immediate, short-term, and long-term aims across a variety of experiential arenas.

McCloskey's overarching holarchical model takes into account a great deal of the research discussed in this review. This model identifies 33 distinct self-regulation EFs that operate within four discrete arenas of involvement: intrapersonal, interpersonal, environment, and symbol system. The model also organizes EFs into various tiers, and each individual possesses his or her own unique and fluid development of functions within each tier and across tiers.

While evidence suggests that EF can be taught and improved upon, a general developmental trend exists. As the frontal-lobe brain areas develop from early childhood through early adulthood, their growth and differentiation mirror the development and refinement of an individual's EFs. The research literature suggests that increases in EF development are large in the younger years and smaller throughout adolescence and adulthood. There is no assurance, however, that all self-regulation EFs will develop at the same rate intraindividually or interindividually. In the school setting, this disparity means that students' EF use can vary greatly among students of the same age, as well as among students of different ages.

Academic achievement and EFs do have a strong relationship. EFs not only facilitate learning, but also are involved in the effective demonstration of the critical skills needed to be a successful student in math, reading, and writing. Despite the strong connection between EF and academic production, educational systems are behind in recognizing the difference between weaknesses in student learning and difficulties in student production. Because the current system does not typically identify and assist students exhibiting difficulties resulting from EF weaknesses, they are at an unfair disadvantage.

Although the relationship between EF and academic performance has been examined, more research is needed to understand how the various components of a more specific model of EF, such as the holarchical model of EF, relate to academic competence. For example, do some specific EFs have a stronger relationship with academic performance than others? Are the relationships between EF and academic competence similar for different age groups, different genders, and different ethnic groups? The current study will examine these questions in more detail through analysis of the standardization sample of teacher ratings of students' EFs collected during the norms development of the McCloskey Executive Functions Scale (MEFS; McCloskey, 2016).

Chapter 3

Methods

This study will examine archival data collected during the standardization of the McCloskey Executive Functions Scale Teacher Report Form (MEFS-TR, Appendix A).

Source of Data

The source of the archival data to be used in this study is the MEFS-TR item raw score file that was created from the standardization data collection file. The data were collected during the scale standardization project during the 2013-2014 and 2014-2015 school years.

Data

The data used for this study are the teachers' ratings of students collected with the MEFS-TR. Teachers' ratings reflected teachers' perceptions of the frequency and effectiveness of students' performance of behaviors, and students' performance of behaviors reflected their degree of use or disuse of executive functions (EFs) and executive skills.

During the MEFS standardization, teachers' ratings were collected for a diverse sample of 813 children and adolescents rated by 254 teachers from 167 communities in 29 states. The student sample's demographic characteristics closely approximate the 2010 U.S. Census percentages.

Teachers rated each student with a pool of 104 items that represented 31 self-regulation EFs organized into seven self-regulation clusters, three self-realization EFs, and two self-determination EFs. (See Appendix A for the MEFS-TR standardization data collection form.)

Self-regulation items were rated on a 6-point scale ranging from 0 to 5. Appendix B shows the MEFS-TR rating rubric.

Characteristics of the Teacher Raters

The teachers who provided the MEFS-TR ratings were regular- and special-education teachers from across the United States. A total of 255 teachers completed ratings on 1,127 children and adolescents who were their students. Of the 255 teachers, 11.4% were male and 88.6% were female. Teachers were allowed to rate a maximum of five subjects, and the majority of them did, with the mean number of students rated being 4.41.

Characteristics of the Rated Students

The teachers in the MEFS standardization sample rated 1,000 students. The rated student sample consisted of 200 subjects (100 male and 100 female) in each of five age groups. Students were from 167 communities in 29 states. Of the sample, 18.7% consisted of individuals with disabilities. The sample of students was collected to match, as closely as possible, a nationally representative sampling plan defined by targeted percentages of subjects based on U.S. demographic data.

Variables Used in the Analyses

The variables used in the data analyses included (a) raw scores based on teachers' ratings for seven self-regulation EF clusters (Attention, Engagement, Optimization, Efficiency, Memory, Inquiry, and Solution), (b) raw scores from teachers' ratings of the 104 items of the MEFS, (c) demographic data for student age, and (d) teachers' ratings of student academic competence (below average, average, above average).

Psychometric Properties of MEFS

Each MEFS item consists of six potential responses:

5-AA = ALMOST ALWAYS does it on own without prompting

4-F = FREQUENTLY does it on own without prompting

3-S = SELDOM does it on own without prompting

2-AP = Does it, but only AFTER PROMPTING

1-DA = Does it only with DIRECT ASSISTANCE

0-UA = UNABLE to do it even with ASSISTANCE

The rating options for the items comprising the Self-Realization and Self-Determination facets were:

3-VO = Does this VERY OFTEN

2-O = Does this OFTEN

1-S = Does this SOMETIMES, but not much

0-N = NEVER does this

MEFS Self-Regulation items consisted of six pairs of items intended to assess the rater's consistency of responding. Inconsistent ratings on the forms completed on the standardization norming sample were minimal. The inconsistency items are provided in Appendix C.

Statistical Analyses

Data analyses employed descriptive and inferential statistical analysis techniques to examine differences in teachers' ratings of EF clusters and differences in teachers' ratings of EF clusters when students are grouped by academic competence rating category (above average, average, below average) and age (5 – 6 years, 7 – 8 years, 9 – 10 years, 11 – 13 years, 14 – 18 years).

Multivariate analysis of variance (MANOVA) was performed to determine whether EF ratings for each of these categories were significantly different. In order to examine the relationships among academic competence level and EF scores and age and EF scores, separate analyses of variance (ANOVAs) were conducted for each EF cluster and specific function. Post hoc analyses were conducted to follow up on significant differences among groups.

Chapter 4

Results

This chapter presents the data analyses of the teachers' MEFS ratings at the executive function (EF) cluster and specific EF levels, respectively, grouped by teacher judgments of student academic competence and across student age groups. These data include means and standard deviations for teachers' ratings of EFs at the cluster and specific function levels, as well as a multivariate analysis of variance (MANOVA) of EF ratings by teachers' ratings of the academic competence levels by age, and by age and academic competence level.

The study was conducted using archival data consisting of student demographic information (age, gender, and ethnicity), MEFS scale teachers' ratings of students' EFs, and teachers' ratings of students' academic competence. Ratings were provided by 254 teachers from 167 communities in 29 states. These teachers rated a diverse sample of 1,000 students. Students from the clinical population were excluded from this study, reducing the total sample size to 813. Table 1 shows an overview of the sample demographics and the academic competence levels, as rated by the surveyed teachers.

Table 1

Sample Demographics

Category	Sample (*n*)	Sample (%)
Academic skills rating		
Above average	173	21.3
Average	559	68.8
Below average	81	10.0
Age (years)		
5-6	181	22.3
7-8	167	20.5
9-10	159	19.6
11-13	167	20.5
14-18	139	17.1
Gender		
Male	442	54.4
Female	371	45.6
Race/ethnicity		
African American	116	14.3
Asian	29	3.6
Hispanic	169	20.8
Native American	7	.9
Other	21	2.6
White	471	57.9

It was hypothesized that age and teachers' judgments of student academic competence level would be systematically related to an individual's EFs across the seven clusters (Attention, Engagement, Optimization, Efficiency, Memory, Inquiry, and Solution) as measured by the MEFS. Five age groups were created, ages 5 to 6 years, ages 7 to 8 years, ages 9 to 10 years, ages 11 to 13 years, and ages 14 to 18 years. These age ranges correspond to early, middle, and late elementary-school, middle-school, and high-school years. The three academic competence level groups designated as "above average," "average," and "below average" are based on the teachers' ratings from a single, 3-point survey question. In that these academic competence ratings were thought to be correlated with EFs and that controlling for the number of comparisons among variables was desired, a MANOVA for all seven executive clusters across all three categories of academic competence was conducted. All analyses are based on raw score sums for each EF cluster.

The results of the MANOVA testing the interaction of academic competence level and age group with EF scores are shown in Table 2

Table 2

Summary of MANOVA Results

Source of variation	Wilks's lambda	*F* value	*df*	*p*
Academic competence	.652	26.966	14	.000
Age	.947	1.551	28	.033
Age x academic competence	.923	1.136	56	.227

Research Question 1: Do teachers' ratings of students' executive functions differ significantly among groups of different-aged students?

The results from the MANOVA demonstrated that there was a statistically significant effect of age on the executive scores, $F(28, 2857.02) = 1.551$, $p < .05$, Wilks' $\Lambda = .947$. In order to examine the relationships between age groups and EF cluster scores, separate 5 x 1 ANOVAs were conducted for each EFs cluster. As shown in Table 3, ANOVAs of EF cluster ratings by age group produced statistically significant results for all seven EF clusters.

Table 3

Between-Subjects Analysis for the Executive Function Clusters by Age

Cluster	*F* value	*df*	*p*	η^2
Attention	3.42	4	.009	.02
Engagement	3.16	4	.014	.02
Optimization	5.40	4	.000	.03
Efficiency	8.25	4	.000	.04
Memory	8.05	4	.000	.04
Inquiry	10.90	4	.000	.05
Solution	8.58	4	.000	.04

Based on the statistically significant results of each of the ANOVAs completed, post hoc analyses using Tukey’s HSD procedure were conducted for each EF cluster. The follow-up tests compared the EF cluster score means obtained for subjects grouped by the five age levels. Tables 4 and 5 show the total raw score means and standard deviations, as well as the mean item scores (total raw score divided by the number of items in the cluster) of each EF cluster for each of the five age groups.

Table 4

Summary of Statistically Significant Results for Executive Function Cluster by Age Group

Cluster	Significant Results Among Age Groups
Attention	No significant differences among age groups
Engagement	No significant differences among age groups
Optimization	Group 1 < Group 5
Efficiency	Group 1 < Groups 2, 3, 5
Memory	Group 1 < Groups 2, 3, 5 Group 4 < Group 5
Inquiry	Group 1 < Groups 2, 3, 5 Group 4 < Group 5
Solution	Group 1 < Groups 2, 5 Group 4 < Group 5

Table 5

Executive Function (EF) Clusters Total Raw Scores, Standard Deviations, and Item Mean Scores by Age

EF cluster	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means [a]	*SD*	Means [a]	*SD*	Means [a]	*SD*	Means [a]	*SD*	Means [a]	*SD*
Attention	24.15 (4.03)	4.803	25.53 (4.26)	4.390	25.38 (4.23)	4.429	24.63 (4.11)	5.056	25.66 (4.28)	3.885
Engagement	90.14 (4.10)	16.075	94.79 (4.31)	14.182	94.36 (4.29)	14.013	91.37 (4.15)	16.957	94.17 (4.28)	14.362
Optimization	54.34 (3.88)	10.866	57.67 (4.12)	9.441	57.62 (4.12)	9.855	56.64 (4.05)	10.825	59.43 (4.25)	9.997
Efficiency	51.87 (3.71)	13.168	57.40 (4.10)	10.637	56.34 (4.02)	10.797	54.84 (3.91)	11.895	58.54 (4.18)	11.055
Memory	27.32 (3.90)	6.624	29.49 (4.21)	5.572	29.47 (4.21)	4.913	28.34 (4.05)	5.776	30.60 (4.37)	4.731
Inquiry	39.05 (3.55)	10.573	43.40 (3.95)	8.337	43.16 (3.92)	8.639	41.47 (3.77)	9.217	45.29 (4.12)	8.096
Solution	46.90 (3.61)	11.903	51.11 (3.93)	10.817	50.62 (3.89)	10.233	49.04 (3.77)	11.343	53.72 (4.13)	9.824

[a] The mean scores in parentheses are the mean item scores for each cluster.

Research Question 1a: Does the relationship between teachers' ratings of executive functions and student age vary depending on the type of executive function being rated?

Comparisons of the mean teachers' ratings within each EF cluster indicated some significant differences among age group mean ratings, but no single pattern of statistically significant differences in mean scores across age groups emerged across the seven EF clusters. Across age groups, the Attention Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 4.03) and Age Groups 2 (mean = 4.26) and 5 (mean =

4.28). The Engagement Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 4.10) and Age Group 2 (mean = 4.31). The Optimization Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 3.88) and Age Group 2 (mean = 4.12), Age Group 3 (mean = 4.12), and Age Group 5 (mean = 4.25). The Efficiency Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 3.71) and Age Group 2 (mean = 4.10), Age Group 3 (mean = 4.02), and Age Group 5 (mean = 4.18), and statistically significant differences between Age Group 4 (mean = 3.91) and Age Group 2 (mean = 4.10), Age Group 3 (mean = 4.02), and Age Group 5 (mean = 4.18). The Memory Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 3.90) and Age Group 2 (mean = 4.21), Age Group 3 (mean = 4.21), and Age Group 5 (mean = 4.37), and statistically significant differences between Age Group 5 (mean = 4.37) and Age Group 1 (mean = 3.90), and Age Group 4 (mean = 4.05).

The Inquiry Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 3.55) and Age Group 2 (mean = 3.95), Age Group 3 (mean = 3.92), and Age Group 5 (mean = 4.12), and statistically significant differences between Age Group 5 (mean = 4.12) and Age Group 1 (mean = 3.55), and Age Group 4 (mean = 3.77). Likewise, the Solution Cluster follow-up analyses indicated statistically significant differences between Age Group 1 (mean = 3.61) and Age Group 2 (mean = 3.93), Age Group 3 (mean = 3.89), and Age Group 5 (mean = 4.13), and statistically significant differences between Age Group 5 (mean = 4.13) and Age Group 1 (mean = 3.61), and Age Group 4 (mean = 3.77).

Although not always reflecting statistically significant differences, a clear pattern emerged among the mean scores across age groups for all seven of the EF clusters; Group 1 scores consistently were the lowest of all age group mean scores for all seven clusters, and Group 4 mean scores were second lowest mean scores of all age groups for all seven clusters.

Based on the item rating structure of the MEFS, item means between 4.0 and 5.0 represent EF strengths (almost always or frequently does on own without prompting), item means between 2.0 and 3.9 represent EF deficits (seldom does without prompting or always requires prompting in order to do), and item means between 0.0 and 1.9 represent executive-skill deficits (cannot do without direct assistance or cannot do even with direct assistance).

In addition to the statistically significant differences among age groups, the mean item scores for the Attention and Engagement Clusters were above 4.0 and in the EF strength range for all five age groups. For the Optimization and Memory Clusters, in addition to some statistically significant differences among age groups, mean item scores dipped below 4.0 and into the EF deficit range for Age Group 1 while the mean item scores of the other four age groups were above 4.0 in the EF strength range.

For the Efficiency Cluster, in addition to some statistically significant differences among age groups, mean item scores were below 4.0 and in the EF deficit range for Age Groups 1 and 4 while the mean item scores for Age Groups 2, 3, and 5 were above 4.0 in the EF strength range. For the Inquiry and Solution Clusters, mean item scores dipped below 4.0 and into the EF deficit range for Age Groups 1, 2, 3, and 4 while the mean item score for Age Group 5 was above 4.0 in the EF strength range.

Research Question 1b: Does the relationship between teachers' ratings of executive functions and student age vary depending on the type of executive function being rated?

A series of ANOVAs was conducted to determine if teachers' ratings for each of the 31 self-regulation EFs varied by age group. As shown in Table 9, the ANOVAs identified statistically significant differences among teachers' ratings of individual self-regulation EFs by age group for 24 of the 31 self-regulation EFs.

Within the Attention Cluster, there were no statistically significant differences among age groups for Focus; within the Engagement Cluster, there were no statistically significant differences among age groups for Initiate, Effort, Inhibit, Stop, Pause, and Shift. For the Optimization, Efficiency, Memory, Inquiry, and Solution Clusters, there were statistically significant differences among age groups for all self-regulation EFs included in these clusters.

Based on the statistically significant results of some of the ANOVAs completed, post hoc analyses using Tukey's HSD procedure were conducted for 26 of the 31 self-regulation EFs. The follow-up tests compared the EF mean teachers' ratings obtained for subjects grouped by the five age levels. Table 6 shows the total raw score means and standard deviations, as well as the item score means (total raw score divided by the number of items in the cluster), for each self-regulation EF for each of the five age groups.

Table 6

Between-Subjects Analysis for the 31 Self-Regulation Executive Functions by Age

Cluster	*F* value (2, 798)	*df*	*p*	η^2
Attention cluster				
Aware	3.85	4	.004	.02
Focus	2.39	4	.049	.01
Sustain	3.582	4	.007	.02
Engagement cluster				
Initiate	2.277	4	.059	.01
Effort	1.445	4	.217	.01
Inhibit	3.127	4	.014	.02
Stop	1.636	4	.163	.01
Pause	3.243	4	.012	.02
Flexible	4.920	4	.001	.02
Shift	1.383	4	.238	.01
Optimization cluster				
Modulate	1.879	4	.112	.01
Monitor	7.070	4	.000	.03
Correct	4.931	4	.001	.02
Balance	5.416	4	.000	.03
Memory cluster				
Hold	9.065	4	.000	.04
StoreRetrieve	6.856	4	.000	.03

Efficiency cluster				
SenseTime	22.985	4	.000	.10
Sequence	6.827	4	.000	.03
Execute	4.006	4	.003	.02
Pace	12.776	4	.000	.06
Inquiry cluster				
Gauge	6.009	4	.000	.03
Anticipate	7.188	4	.000	.03
EstimateTime	15.283	4	.000	.07
Analyze	10.197	4	.000	.05
Compare	7.752	4	.000	.04
Solution cluster				
Generate	5.177	4	.000	.02
Associate	7.152	4	.000	.03
Organize	5.247	4	.000	.03
Plan	6.567	4	.000	.03
Prioritize	10.062	4	.000	.05
Decide	9.352	4	.000	.04

Tables 7 and 8 show the total raw score means and standard deviations, as well as the mean item scores (total raw score divided by the number of items in the cluster) of each self-regulation EF for each of the five age groups.

Table 7

Summary of Statistically Significant Results for Self-Regulation Executive Functions by Age Group

Self-Regulation executive function	Significant results among age groups
Attention cluster	
Aware	No significant differences among age groups
Focus	No significant differences among age groups
Sustain	Group 1 < Group 2
Engagement cluster	
Initiate	No significant differences among age groups
Effort	No significant differences among age groups
Inhibit	No significant differences among age groups
Stop	No significant differences among age groups
Pause	No significant differences among age groups
Flexible	Group 1 < Groups 2, 5
Shift	No significant differences among age groups
Optimization cluster	
Modulate	No significant differences among age groups
Monitor	Group 1 < Groups 2, 5
Correct	Group 1 < Group 5
Balance	Group 1 < Group 5
Memory cluster	
Hold	Group 1 < Groups 2, 3, 5
StoreRetrieve	Group 1 < Groups 2, 3, 5
Efficiency cluster	

SenseTime	Group 1 < Groups 2, 3, 4, 5
Sequence	Group 1 < Groups 2, 5
	Group 4 < Group 5
Execute	Group 1 < Group 2
Pace	Group 1 < Groups 2, 3, 4, 5
Inquiry cluster	
Gauge	Group 1 < Groups 2, 3, 5
Anticipate	Group 1 < Groups 2, 3, 5
EstimateTime	Group 1 < Groups 2, 3, 4, 5
	Group 4 < Group 5
Analyze	Group 1 < Groups 2, 3, 5
Compare	Group 1 < Groups 2, 3, 4, 5
Solution cluster	
Generate	Group 1 < Group 5
	Group 4 < Group 5
Associate	Group 1 < Groups 2, 5
	Group 4 < Group 5
Organize	Group 1 < Group 5
	Group 4 < Group 5
Plan	Group 1 < Group 5
	Group 4 < Group 5
Prioritize	Group 1 < Groups 2, 3, 4, 5
Decide	Group 1 < Groups 3, 5
	Group 4 < Group 5

Table 8

Executive Function (EF) Clusters Total Raw Scores, Standard Deviations, and Item Mean Scores by Age

EF	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Aware	8.27 (4.14)	1.604	8.63 (4.32)	1.499	8.70 (4.35)	1.508	8.26 (4.13)	1.873	8.78 (4.89)	1.383
Focus	8.03 (4.15)	1.663	8.43 (4.22)	1.596	8.39 (4.20)	1.571	8.21 (4.11)	1.714	8.51 (4.26)	1.364
Sustain	7.85 (3.93)	1.830	8.47 (4.24)	1.586	8.30 (4.15)	1.682	8.16 (4.08)	1.773	8.37 (4.19)	1.426
Initiate	8.28 (4.14)	1.762	8.59 (4.30)	1.595	8.70 (4.35)	1.492	8.26 (4.13)	1.732	8.45 (4.23)	1.519
Effort	8.25 (4.13)	1.673	8.47 (4.24)	1.508	8.45 (4.23)	1.529	8.11 (4.06)	1.835	8.26 (4.13)	1.496
Inhibit	28.65 (4.09)	5.820	30.21 (4.32)	4.990	30.30 (4.33)	4.982	29.13 (4.16)	6.119	30.07 (4.30)	5.089
Stop	12.07 (4.02)	2.682	12.72 (4.24)	2.270	12.50 (4.17)	2.587	12.34 (4.11)	2.690	12.58 (4.19)	2.621
Pause	8.08 (4.04)	1.686	8.59 (4.30)	1.553	8.60 (4.30)	1.623	8.35 (4.18)	1.628	8.54 (4.27)	1.436
Flexible	16.36 (4.09)	3.018	17.39 (4.35)	2.895	17.14 (4.29)	2.836	16.68 (4.17)	3.426	17.62 (4.41)	2.506
Shift	8.45 (4.23)	1.743	8.82 (4.41)	1.599	8.68 (4.34)	1.564	8.50 (4.25)	1.679	8.65 (4.33)	1.601

Modulate	21.05 (4.21)	3.580	21.60 (4.32)	3.682	21.77 (4.36)	3.334	21.49 (4.30)	3.834	22.11 (4.42)	3.505
Monitor	14.77 (3.69)	3.754	16.16 (4.04)	3.001	15.86 (3.97)	3.402	15.87 (3.97)	3.490	16.68 (4.17)	3.107
Correct	7.40 (3.70)	1.982	8.01 (4.01)	1.589	7.99 (4.00)	1.821	7.74 (3.87)	2.009	8.24 (4.12)	1.743
Balance	11.12 (3.71)	3.027	11.90 (3.97)	2.597	12.00 (4.00)	2.488	11.54 (3.85)	2.627	12.41 (4.14)	2.431
Hold	7.86 (3.93)	2.111	8.53 (4.27)	1.849	8.54 (4.27)	1.594	8.28 (4.14)	1.852	9.02 (4.51)	1.299
StoreRetrieve	19.46 (3.89)	4.738	20.96 (4.19)	3.924	20.93 (4.19)	3.574	20.06 (4.01)	4.195	21.58 (4.32)	3.635
SenseTime	6.10 (3.05)	2.278	7.43 (3.72)	2.174	7.60 (3.80)	1.932	7.48 (3.74)	1.945	8.15 (4.08)	1.785
Sequence	8.01 (4.05)	1.894	8.63 (4.32)	1.592	8.51 (4.26)	1.634	8.11 (4.06)	1.702	8.80 (4.40)	1.281
Execute	30.99 (3.87)	7.667	33.54 (4.19)	6.078	32.62 (4.07)	6.553	31.69 (3.96)	7.472	33.31 (4.16)	7.007
Pace	6.77 (3.39)	2.457	7.79 (3.90)	1.780	7.61 (3.81)	1.852	7.55 (3.78)	1.762	8.28 (4.14)	1.732
Gauge	7.46 (3.73)	2.010	8.09 (4.05)	1.496	8.09 (4.05)	1.614	7.78 (3.89)	1.694	8.29 (4.15)	1.634
Anticipate	11.20 (3.73)	3.067	12.34 (4.11)	2.389	12.18 (4.06)	2.596	11.73 (3.91)	2.725	12.62 (4.21)	2.363
EstimateTime	6.71 (3.36)	2.297	7.83 (3.92)	1.800	7.72 (3.86)	1.865	7.46 (3.73)	1.832	8.28 (4.14)	1.561
Analyze	6.91 (3.46)	2.118	7.65 (3.83)	1.756	7.74 (3.87)	1.745	7.27 (3.64)	2.004	8.15 (4.08)	1.685
Compare	6.77 (3.39)	2.258	7.49 (3.75)	1.849	7.43 (3.72)	1.868	7.23 (3.62)	1.882	7.96 (3.98)	1.809
Generate	7.04 (3.52)	1.925	7.64 (3.82)	1.851	7.43 (3.72)	1.957	7.13 (3.57)	2.037	7.86 (3.93)	1.725

Associate	7.22 (3.61)	2.167	7.95 (3.98)	1.776	7.75 (3.38)	1.778	7.51 (3.76)	1.766	8.23 (4.12)	1.648
Organize	7.37 (3.69)	2.042	7.98 (3.99)	1.945	7.86 (3.93)	1.861	7.50 (3.25)	2.173	8.25 (4.13)	1.766
Plan	11.07 (3.69)	3.080	11.89 (3.96)	2.733	11.72 (3.91)	2.558	11.60 (3.87)	2.854	12.63 (4.21)	2.384
Prioritize	6.83 (3.44)	2.212	7.69 (3.85)	1.935	7.72 (3.86)	1.786	7.47 (3.74)	1.975	8.16 (4.08)	1.741
Decide	7.36 (3.68)	1.974	7.96 (3.98)	1.917	8.13 (4.07)	1.771	7.83 (3.92)	1.872	8.58 (4.29)	1.565

[a]The mean scores in parentheses are the mean item scores for each cluster

Comparisons of the mean teachers' ratings with follow-up analyses for 26 of the 31 self-regulation EFs indicated statistically significant differences among age group mean ratings, with one consistent difference that emerged for all comparisons: The mean teachers' ratings for Age Group 1 were always significantly lower than the mean teachers' ratings for Age Group 5. Additional patterns were noted, but these patterns varied based on the cluster of EFs being considered.

The follow-up analyses within the Attention Cluster indicated no statistically significant differences among any of the age groups for Aware, even though the ANOVA analysis produced a statistically significant F value. For Focus, the ANOVA did not indicate any statistically significant difference among age groups. For Sustain, the only significant difference was that the mean item rating for Age Group 2 (mean = 4.24) was significantly greater than the mean item rating for Age Group 1 (mean = 4.15).

The ANOVA analyses within the Engagement Cluster indicated no statistically significant differences among any of the age groups for the Initiate, Effort, Inhibit, Stop, Pause, and Shift EFs. The follow-up analyses for Flexible indicated that the mean item rating for Age Group 5 was significantly greater than the mean item rating for Age Group 1.

The ANOVA analyses within the Optimization Cluster indicated no statistically significant differences among any of the age groups for Modulate. The follow-up analyses for Monitor, Correct, and Balance all indicated a statistically significant difference wherein the mean ratings for Age Group 5 were greater than the mean ratings for Age Group 1. Additionally, the analysis for Monitor indicated that the mean rating for Age Group 2 was greater than the mean rating for Age Group 1.

Within the Efficiency Cluster, follow-up analyses indicated the following statistically significant differences: for Sense Time, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 3, 4, and 5; for Sequence, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2 and 5, and the mean rating for Age Group 5 was significantly greater than the mean rating for Age Group 4; for Routines, the mean rating for Age Group 1 was significantly less than the mean rating for Age Group 2; for Pace, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2, 3, 4, and 5, and the mean rating for Age Group 5 was significantly greater than the mean rating for Age Group 4.

Within the Memory Cluster, follow-up analyses indicated the following statistically significant differences: for Hold/Manipulate, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2, 3, and 5, and the mean rating for Age Group 5 was significantly greater than the mean rating for Age Group 4; for Store/Retrieve, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2, 3, and 5, and the mean rating for Age Group 5 was significantly greater than the mean rating for Age Group 4.

Within the Inquiry Cluster, follow-up analyses indicated the following statistically significant differences: for all five EFs (Gauge, Anticipate, Estimate Time, Analyze, and Compare), the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2, 3, and 5; additionally, for Estimate Time, the mean rating for Age Group 4 was significantly greater than the mean rating for Age Group 1; for Estimate Time, Analyze, and Compare, the mean rating for Age Group 5 was significantly greater than the mean rating for Age Group 4.

Within the Solution Cluster, follow-up analyses indicated the following statistically significant differences: for Generate and Plan, the mean rating for Age Group 5 was significantly greater than the mean ratings for Age Groups 1 and 4; for Associate and Organize, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2 and 5, and the mean rating for Age Group 5 was significantly greater than the mean ratings for Age Groups 1 and 4; for Prioritize, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 2, 3, 4 and 5; for Decide, the mean rating for Age Group 1 was significantly less than the mean ratings for Age Groups 3 and 5, and the mean rating for Age Group 5 was significantly greater than the mean rating for Age Group 4.

Based on the item rating structure of the MEFS, item means between 4.0 and 5.0 represent EF strengths (almost always or frequently does on own without prompting); item means between 2.0 and 3.9 represent EF deficits (seldom does without prompting or always requires prompting in order to do); and item means between 0.0 and 1.9 represent executive-skill deficits (cannot do without direct assistance or cannot do even with direct assistance).

In addition to the statistically significant differences among age groups noted in the previous paragraphs, specific ratings patterns are evident among the EFs within the seven clusters. Within the Attention Cluster, mean item scores for Aware and Focus were above 4.0 and in the EF strength range for all five age groups. For Sustain, the mean item score for Age Group 1 was slightly below 4.0 and in the EF deficit range, whereas the mean item ratings for Age Groups 2, 3, 4, and 5 were all above 4.0 and in the EF strength range.

For the Engagement Cluster, the mean item ratings for all seven self-regulation EFs were above 4.0 and in the EF strength range for all age groups. For the Optimization Cluster, the mean item rating for Modulate was above 4.0 and in the EF strength range for all age groups; for

Monitor, the mean item score for Age Group 1 was slightly below 4.0 and in the EF deficit range, whereas the mean item ratings for Age Groups 2, 3, 4, and 5 were above 4.0 and in the EF strength range; for Correct, the mean item scores for Age Groups 1 and 4 were below 4.0 and in the EF deficit range, whereas the mean item ratings for Age Groups 2, 3, and 5 were above 4.0 and in the EF strength range; for Balance, the mean item scores for Age Groups 1, 2, and 4 were below 4.0 and in the EF deficit range, whereas the mean item ratings for Age Groups 3 and 5 were above 4.0 and in the EF strength range.

For the Efficiency Cluster, the mean item ratings for Sequence were above 4.0 and in the EF strength range for all age groups. Mean item ratings for Sense Time and Pace were below 4.0 and in the EF deficit range for Age Groups 1, 2, 3, and 4, whereas the mean item rating for Group 5 was above 4.0 and in the EF strength range. Mean item ratings for Routines were below 4.0 and in the EF deficit range for Age Groups 1 and 4, whereas mean item ratings for Age Groups 2, 3, and 5 were above 4.0 and in the EF strength range.

For the Memory Cluster, the mean item scores for both Hold/Manipulate and Store/Retrieve for Age Group 1 were slightly below 4.0 and in the EF deficit range, whereas the mean item ratings for Age Groups 2, 3, 4, and 5 were above 4.0 and in the EF strength range.

For the Inquiry Cluster, the mean item ratings for Gauge and Anticipate were below 4.0 and in the EF deficit range for Age Groups 1 and 4, whereas mean item ratings for Age Groups 2, 3, and 5 were above 4.0 and in the EF strength range. Mean item ratings for Estimate Time and Analyze were below 4.0 and in the EF deficit range for Age Groups 1, 2, 3, and 4, whereas the mean item rating for Group 5 was above 4.0 and in the EF strength range. For Compare, the mean item ratings for all age groups were below 4.0 and in the EF deficit range.

For the Solution Cluster, the mean item ratings for Associate, Organize, Plan, and Prioritize were below 4.0 and in the EF deficit range for Age Groups 1 and 4, whereas mean item ratings for Age Groups 2, 3, and 5 were above 4.0 and in the EF strength range. Mean item ratings for Decide were below 4.0 and in the EF deficit range for Age Groups 1, 2, and 4, whereas the mean item ratings for Age Groups 3 and 5 were above 4.0 and in the EF strength range. For Generate, the mean item ratings for all age groups were below 4.0 and in the EF deficit range.

Research Question 2: Do teachers' ratings of students' executive functions differ significantly among groups of students whose academic competence is judged to be above average, average, and below average?

The results from the MANOVA did indicate that EF cluster scores vary by academic competence level, $F(14,1584) = 26.996$, $p < .001$, Wilks's $\Lambda = .625$. In order to examine the relationships between academic competence level and EF cluster scores, separate 3 x 1 analyses of variance (ANOVAs) were conducted for each EF cluster. As shown in Table 9, ANOVAs of EF cluster ratings grouped by academic competence levels produced statistically significant results for all seven EF clusters.

Table 9

Between-Subjects Analysis for Executive Function Clusters by Academic Competence Group

Cluster	*F* value (2, 798)	*df*	*p*	η^2
Attention	130.93	2	.000	.24
Engagement	73.23	2	.000	.15
Optimization	103.60	2	.000	.20
Efficiency	179.82	2	.000	.31
Memory	191.06	2	.000	.32
Inquiry	138.55	2	.000	.25
Solution	149.96	2	.000	.27

Based on the statistically significant results of each of the ANOVAs completed, post hoc analyses using Tukey's HSD procedure were conducted for each EF cluster. The follow-up tests compared the EF cluster score means obtained for subjects grouped by the three academic competence levels. Comparisons of the mean teachers' rating within each EF cluster indicated statistically significant differences among all three levels of academic competence for all seven EF clusters. For each EF cluster, the mean of teachers' ratings of EFs increased significantly from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Table 10 shows the total raw score means and standard deviations, as well as mean item scores (total raw score divided by the number of items in the cluster) for each EF cluster for each of the three academic competence level groups.

Table 10

Executive Function (EF) Clusters Total Raw Scores, Standard Deviations, and Item Mean Scores by Academic Competence Group

EF cluster	Academic competence					
	Above average		Average		Below average	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Attention	27.80 (4.60)	3.03	25.03 (4.17)	4.03	19.11 (3.19)	5.26
Engagement	100.47 (4.56)	12.00	92.73 (4.25)	13.85	77.52 (3.51)	19.07
Optimization	63.40 (4.53)	7.95	56.69 (4.04)	9.28	45.58 (3.25)	11.35
Efficiency	63.61 (4.54)	7.46	55.64 (3.97)	9.96	38.49 (2.74)	12.98
Memory	32.98 (4.71)	3.54	28.93 (4.13)	4.64	20.57 (2.94)	6.92
Inquiry	48.96 (4.45)	6.85	41.88 (3.81)	8.15	31.12 (2.83)	9.49
Solution	58.07 (4.46)	7.68	49.67 (3.82)	9.57	36.05 (2.78)	12.22

[a] The mean scores in parentheses are the mean item scores for each cluster .

Research Question 2a: Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence vary depending on the type of executive function being rated?

Based on the item rating structure of the MEFS, mean item scores between 4.0 and 5.0 represent EF strengths (almost always or frequently does on own without prompting); mean item scores between 2.0 and 3.9 represent EF deficits (seldom does without prompting or always requires prompting in order to do); and mean item scores between 0.0 and 1.9 represent executive-skill deficits (cannot do without direct assistance or cannot do even with direct assistance). Mean item ratings of all seven EF clusters produced scores in the EF deficit range for the Below Average academic competence group. In contrast, mean item ratings for the group that was judged as Average in academic competence were in the EF strength range for the Attention, Engagement, Optimization, and Memory Clusters but dropped just below 4.0 and into the EF deficit range for the Efficiency, Inquiry, and Solution Clusters with mean item ratings of 3.97, 3.81, and 3.82, respectively. Mean item ratings for the group that was judged as Above Average in academic competence were all above 4.0 and in the EF strength range for all seven EF clusters.

Research Question 2b: Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence vary depending on the specific executive function being rated?

A series of ANOVAs was conducted to determine if teachers' ratings for each of the 31 self-regulation EFs varied by academic competence level. As shown in Table 11, the ANOVAs identified statistically significant differences among teachers' ratings of individual self-regulation EFs by academic competency levels for all 31 self-regulation EFs.

Table 11

Between-Subjects Analysis for the 31 Self-Regulation Executive Functions by Academic Competence Group

Cluster	*F* Value (2, 798)	*df*	*p*	η^2
Attention cluster				
Aware	128.45	2	.000	.24
Focus	103.63	2	.000	.20
Sustain	102.55	2	.000	.20
Engagement cluster				
Initiate	110.14	2	.000	.21
Effort	106.52	2	.000	.21
Inhibit	39.63	2	.000	.09
Stop	26.95	2	.000	.01
Pause	76.67	2	.000	.16
Flexible	50.37	2	.000	.11
Shift	60.49	2	.000	.13
Optimization cluster				
Modulate	32.05	2	.000	.07
Monitor	120.64	2	.000	.23
Correct	101.64	2	.000	.20
Balance	105.70	2	.000	.21
Memory cluster				
Hold	143.30	2	.000	.26
StoreRetrieve	183.91	2	.000	.31

Efficiency cluster				
SenseTime	95.07	2	.000	.19
Sequence	150.40	2	.000	.27
Execute	181.84	2	.000	.31
Pace	86.51	2	.000	.18
Inquiry cluster				
Gauge	117.00	2	.000	.22
Anticipate	95.73	2	.000	.19
EstimateTime	93.30	2	.000	.19
Analyze	111.90	2	.000	.20
Compare	121.75	2	.000	.23
Solution cluster				
Generate	123.72	2	.000	.23
Associate	152.67	2	.000	.27
Organize	100.73	2	.000	.20
Plan	107.73	2	.000	.21
Prioritize	107.54	2	.000	.21
Decide	87.24	2	.000	.18

Based on the statistically significant results of each of the ANOVAs completed, post hoc analyses using Tukey's HSD procedure were conducted for each of the 31 self-regulation EFs. The follow-up tests compared the EF mean teachers' ratings obtained for subjects grouped by the three academic competence levels. Comparisons of the mean ratings for each EF indicated statistically significant differences among all three levels of academic competence for all 31 self-regulation EFs. For each EF, the mean of teachers' ratings increased significantly from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Table 12 shows the total raw score means and standard deviations, as well as the mean item scores (total raw score divided by the number of items in the cluster) for each self-regulation EF for each of the three academic competence level groups.

Table 12

Self-Regulation Executive Function (EF) Raw Score Means, Standard Deviations, and Item Means by Academic Competence Group

EF cluster	Academic competence					
	Above average		Average		Below average	
Attention Cluster						
	Means [a]	*SD*	Means [a]	*SD*	Means [a]	*SD*
Aware	9.45 (4.75)	.985	8.52 (4.26)	1.425	6.43 (3.22)	1.870
Focus	9.19 (4.60)	1.250	8.30 (4.15)	1.411	6.42 (3.21)	1.857
Sustain	9.17 (4.59)	1.152	8.21 (4.11)	1.529	6.26 (3.13)	1.973
Engagement cluster						
Initiate	9.29 (4.65)	.987	8.49 (4.25)	1.483	6.40 (3.2)	1.979
Effort	9.21 (4.61)	1.090	8.31 (4.16)	1.453	6.37 (3.19)	1.959
Inhibit	31.88 (4.55)	4.642	29.52 (4.28)	4.943	25.65 (3.66)	7.753
Stop	13.35 (4.45)	2.359	12.37 (4.12)	2.447	10.90 (3.63)	3.093
Pause	9.17 (4.56)	1.230	8.44 (4.22)	1.460	6.72 (3.36)	1.951
Flexible	18.24 (4.56)	2.496	16.99 (4.25)	2.787	14.42 (3.61)	3.674
Shift	9.34 (4.67)	1.192	8.62 (4.31)	1.540	7.06 (3.53)	2.064
Optimization cluster						
Modulate	22.92 (4.58)	3.094	21.50 (4.30)	3.470	19.20 (3.84)	4.194
Monitor	17.99 (4.50)	2.749	15.75 (3.94)	2.933	11.70 (2.93)	3.948
Correct	8.99 (4.50)	1.406	7.80 (3.90)	1.687	5.81 (2.91)	1.988
Balance	13.50 (4.50)	1.937	11.64 (3.88)	2.431	8.86 (2.95)	2.970

Memory cluster						
Hold	9.53 (4.77)	1.087	8.42 (4.21)	1.585	5.96 (2.98)	2.182
StoreRetrieve	23.45 (4.69)	2.604	20.51 (4.10)	3.340	14.60 (2.92)	5.132
Efficiency cluster						
SenseTime	8.69 (4.35)	1.590	7.18 (3.59)	1.973	5.16 (2.58)	2.342
Sequence	9.38 (4.69)	1.048	8.43 (4.22)	1.451	6.05 (3.25)	1.910
Execute	36.86 (4.61)	4.305	32.52 (4.07)	5.937	21.83 (2.73)	7.885
Pace	8.68 (4.34)	1.551	7.52 (3.76)	1.865	5.46 (2.73)	2.080
Inquiry cluster						
Gauge	9.02 (4.51)	1.260	7.88 (3.94)	1.564	5.89 (2.95)	1.746
Anticipate	13.59 (4.53)	2.029	11.90 (3.97)	2.438	9.09 (3.03)	3.075
EstimateTime	8.75 (4.38)	1.495	7.49 (3.75)	1.795	5.51 (2.76)	2.180
Analyze	8.84 (4.42)	1.425	7.39 (3.70)	1.770	5.47 (2.74)	1.789
Compare	8.76 (4.38)	1.497	7.22 (3.61)	1.751	5.17 (2.59)	2.120
Solution cluster						
Generate	8.77 (4.39)	1.402	7.28 (3.64)	1.688	5.26 (2.63)	2.184
Associate	9.03 (4.52)	1.186	7.65 (3.83)	1.629	5.28 (2.64)	2.099
Organize	8.89 (4.45)	1.546	7.75 (3.88)	1.795	5.48 (2.74)	2.151
Plan	13.51 (4.50)	1.981	11.64 (3.88)	2.512	8.64 (2.88)	3.152
Prioritize	8.76 (4.38)	1.539	7.49 (3.75)	1.783	5.27 (2.64)	2.145
Decide	9.09 (4.55)	1.309	7.85 (3.93)	1.699	6.11 (3.01)	2.351

[a] The mean scores in parentheses are the mean item scores for each cluster.

Based on the item rating structure of the MEFS, mean item scores between 4.0 and 5.0 represent EF strengths (almost always or frequently does on own without prompting); mean item scores between 2.0 and 3.9 represent EF deficits (seldom does without prompting or always requires prompting in order to do); and mean item scores between 0.0 and 1.9 represent executive-skill deficits (cannot do without direct assistance or cannot do even with direct assistance).

For the group that was judged as Below Average in academic competence, mean item ratings of all of the self-regulation EFs within all seven clusters produced scores in the EF deficit range. In contrast, mean item ratings for the group that was judged as Average in academic competence were in the EF strength range for all of the self-regulation EFs within the Attention, Engagement, and Memory Clusters. Mean scores of the self-regulation EFs within the Optimization Cluster, however, were not uniform; while the item mean score for Modulate was in the EF strength range, the mean item scores for Monitor, Correct, and Balance dropped just slightly below 4.0 and into the EF deficit range, with mean item scores of 3.94, 3.90, and 3.88, respectively. The mean item ratings for the Efficiency Cluster also varied with mean item ratings above 4.0 and in the EF strength range for Sequence and Routines, but ratings dropping below 4.0 and into the EF deficit range for Sense Time and Pace, with mean item ratings of 3.59 and 3.76, respectively. Mean item ratings within the Inquiry and Solution Clusters were consistently poorer, with mean item ratings for the five Inquiry and the 6 Solution EFs all dropping into the upper end of the EF deficit range.

In contrast to the mixed ratings for the Average academic competence group, the mean item ratings for the group that was judged as Above Average in academic competence were all in the EF strength range for all 31 self-regulation EFs within the seven EF clusters.

Research Question 3: Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence change based on student age?

Results from this MANOVA demonstrated that there was no statistically significant interaction effect between age and academic competence across the seven EF clusters, $F(56,4270.36) = 1.135$, $p = .227$, Wilks's $\Lambda = .923$. This means that the relationship between EF ratings and academic competence levels was consistent across all age groups.

Although no statistically significant interaction was found between age and academic competency for EF ratings, the mean ratings, standard deviations, and item ratings for the seven EF clusters were analyzed in order to determine if any important patterns could be observed. This information is presented in Tables 13-19.

Table 13

Attention Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic Competence	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above average	25.50 (4.25)	4.206	27.67 (4.61)	2.880	28.37 (4.73)	2.476	28.21 (4.70)	3.248	28.23 (4.71)	2.257
Average	24.85 (4.14)	4.161	25.68 (4.28)	3.870	25.07 (4.18)	3.844	24.61 (4.10)	4.662	24.91 (4.15)	3.319
Below average	18.14 (3.02)	5.218	19.14 (3.19)	5.736	19.71 (3.29)	6.244	19.36 (3.23)	4.676	19.70 (3.28)	5.208

[a]The mean scores in parentheses are the mean item scores for each cluster .

For the Attention Cluster, for all ages, the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Above-Average students and Average students had mean item ratings above 4.0, the EF strength range. Below-Average students had mean item ratings below 4.0 in the EF deficit range.

Table 14

Engagement Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic competence	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above average	91.27 (4.15)	18.55	100.36 (4.56)	11.019	101.42 (4.61)	9.855	102.15 (4.64)	12.450	102.91 (4.68)	7.868
Average	92.23 (4.19	14.171	95.34 (4.33)	12.964	93.66 (4.26)	12.659	90.95 (4.13)	15.509	90.96 (4.13)	13.299
Below average	75.24 (3.42)	18.000	76.93 (3.50)	17.486	80.57 (3.66)	21.190	77.32 (3.51)	19.360	79.30 (3.60)	22.711

[a]The mean scores in parentheses are the mean item scores for each cluster.

For the Engagement Cluster, for all ages, with one exception (Group 1, Average students were rated slightly higher than Above-Average students), the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above- average academic competence level. Above-Average students and Average students had mean item ratings above 4.0, the EF strength range. Below-Average students had mean item ratings below 4.0, in the EF deficit range.

Table 15

Optimization Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic competence	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above Average	56.64 (4.05)	11.875	62.33 (4.45)	7.708	64.42 (4.60)	7.269	64.55 (4.61)	7.142	65.68 (4.69)	4.764
Average	55.73 (3.98)	9.455	57.95 (4.14)	8.468	56.35 (4.03)	9.206	56.21 (4.02)	10.150	57.54 (4.11)	8.893
Below Average	42.76 (3.05)	11.933	44.29 (3.16)	9.302	48.93 (3.50)	10.440	46.95 (3.35)	10.321	45.60 (3.26)	15.981

[a]The mean scores in parentheses are the mean item scores for each cluster.

For the Optimization Cluster, for all ages, the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Above-Average students and Average students had mean item ratings above 4.0, the EF strength range, with the exception of students rated Average in Age Group 1. Below-Average students had mean item ratings below 4.0 in the EF deficit range.

Table 16

Efficiency Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic competence	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above average	58.55 (4.18)	10.835	64.55 (4.61)	6.510	62.79 (4.49)	7.516	64.24 (4.59)	7.508	65.55 (4.68)	4.786
Average	53.62 (3.83)	10.720	57.88 (4.13)	8.169	55.69 (3.98)	10.006	55.13 (3.94)	10.018	56.39 (4.03)	10.337
Below average	33.33 (2.38)	14.800	36.36 (2.60)	11.008	43.79 (3.13)	12.033	39.27 (2.81)	10.434	43.20 (3.09)	15.317

[a]The mean scores in parentheses are the mean item scores for each cluster.

For the Effiency Cluster, for all ages, the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Above-Average students and Average students had mean item ratings above 4.0, the EF strength range, with the exception of students rated Average in Age Groups 1,3, and 4. Below-Average students had mean item ratings below 4.0 in the EF deficit range.

Table 17

Memory Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic Competence	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above average	30.86 (4.41)	7.039	33.39 (4.77)	2.304	32.92 (4.70)	2.907	33.06 (4.73)	3.102	33.66 (4.81)	2.129
Average	28.19 (4.03)	5.041	29.59 (4.23)	4.359	29.15 (4.16)	4.335	28.34 (4.05)	4.993	29.72 (4.25)	3.979
Below average	17.90 (2.56)	7.529	19.43 (2.78)	7.852	22.57 (3.22)	5.402	21.23 (3.03)	5.407	23.50 (3.36)	8.100

[a]The mean scores in parentheses are the mean item scores for each cluster.

For the Memory Cluster for all ages, the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Above- Average students and Average students had mean item ratings above 4.0, the EF strength range. Below-Average students had mean item ratings below 4.0 in the EF deficit range.

Table 18

Inquiry Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic Competence	Age (Years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above average	43.32 (3.94)	9.443	49.09 (3.63)	6.468	49.55 (4.50)	6.229	49.52 (4.50)	7.181	50.64 (4.60)	4.435
Average	40.04 (3.64)	9.614	43.44 (3.94)	6.793	42.19 (3.85)	7.712	40.89 (3.72)	8.101	43.61 (3.96)	7.163
Below average	28.05 (2.55)	11.196	29.57 (2.69)	8.600	33.29 (3.03)	8.914	32.36 (2.94)	7.461	34.00 (3.09)	11.225

[a]The mean scores in parentheses are the mean item scores for each cluster.

For the Inquiry Cluster, for all ages, the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Only Above-Average students in Age Groups 3, 4, and 5 had mean item ratings above 4.0 the EF strength range. Above-Average students in Age Groups 1 and 2, all Average students, and all Below-Average students had mean item ratings below 4.0 in the EF deficit range.

Table 19

Solution Total Raw Scores, Standard Deviations, and Item Mean Scores for Academic Competence by Age

Academic Competence	Age (years)									
	Group 1: 5-6		Group 2: 7-8		Group 3: 9-10		Group 4: 11-13		Group 5: 14-18	
	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*	Means[a]	*SD*
Above average	52.55 (4.04)	9.898	58.61 (4.51)	6.314	58.16 (4.47)	7.734	58.21 (4.48)	8.908	60.11 (4.62)	5.079
Average	48.20 (3.71)	10.104	51.13 (3.93)	9.062	49.47 (3.81)	8.945	48.59 (3.74)	10.253	51.72 (3.98)	8.683
Below average	32.38 (2.49)	14.309	33.29 (2.56)	12.627	39.00 (3.00)	11.293	37.59 (2.89)	8.359	40.10 (3.08)	14.625

[a]The mean scores in parentheses are the mean item scores for each cluster.

For the Solution Cluster, for all ages, the mean of teachers' ratings of EFs increased from the below-average academic competence level to the average academic competence level and from the average to the above-average academic competence level. Above-Average students had mean item ratings above 4.0, the EF strength range. Average and Below-Average students had mean item ratings below 4.0 in the EF deficit range

Chapter 5

Discussion

The purpose of the research study was to determine if teachers' ratings of students' executive functions (EFs) differ significantly among groups of students whose academic competence is judged to be above average, average, and below average and if teachers' ratings of students' EFs differ significantly by age. Further, the study sought to determine if the relationship between teachers' ratings of EFs and teachers' judgments of academic competence would change based on student age.

Research Question 1. Do teachers' ratings of students' executive functions differ significantly among groups of different-aged students?

Multivariate analysis of variance (MANOVA) results indicated that EFs differ significantly among different-aged groups of students. Teachers' ratings of EFs, overall, were highest for the oldest group of students and lowest for the youngest group of students.

Research Question 1a: Does the relationship between teachers' ratings of executive functions and student age vary depending on the type of executive function being rated?

Results of the analyses conducted with the McCloskey Executive Functions Scale (MEFS) nonclinical standardization sample indicated that the relationship between teachers' ratings of EFs and student age does vary depending on the type of EF being rated. While a significant relationship was observed for each cluster of EFs, no single pattern emerged. Scores for the age groups themselves differed significantly between consecutive age groups for different clusters. For example, Attention scores increased significantly only from Age Group 1 (ages 5 – 6 years) to Age Group 2 (ages 7 – 8 years) while Efficiency scores increased significantly from Age Group 1 (ages 5 – 6 years) to Age Group 2 (ages 7 8 years) and for Age Group 3 (ages 9 –

10 years) and Group 5 (ages 14 – 18 years). This type of variability among clusters suggests that the different types of EFs show significant growth at different times and/or different rates.

This variability was also evident based on the mean item ratings for the specific age groups within each cluster. Mean ratings for Attention and Engagement were consistent EF strengths for all five age groups. Mean ratings for Optimization and Memory were consistent EF strengths except for Age Group 1 (ages 5 – 6 years), where the mean item score was in the EF deficit range. Mean ratings for Optimization and Memory were consistent EF strengths except for Age Group 1 (ages 5 – 6 years) and Age Group 4 (ages 11 13 years), where the mean item scores were in the EF deficit range. Mean ratings for Inquiry and Solution were consistent EF deficits for the first four age groups, but were consistent EF strengths for the oldest age group.

Despite this variability across age groups for the various clusters, the data showed that for all EF clusters and self-regulation EFs, a consistent pattern was demonstrated. For all clusters, there appears to be a significant increase in raw scores from the 5- to 6-year age group to the 7- to 8-year age group and little or no change from the 7- to 8-year age group to the 9- to10- year age group. Additionally, a noticeable though nonsignificant decrease in raw scores was observed from the 9- to 10-year age group to the 11- to 13-year age group, and a significant increase in raw scores from the 11- to 13-year age group to the 14- to 18-year age group.

Research Question 1b: Does the relationship between teachers' ratings of executive functions and student age vary depending on the specific executive function being rated?

Statistically significant differences among teachers' ratings of individual self-regulation EFs were found by age group for 24 of the 31 self-regulation EFs. No significant differences were found for Focus, Initiate, Effort, Inhibit, Stop Pause, and Shift. Statistically significant differences between specific age groups varied depending on the specific EF being rated. Some functions showed no significant differences among age groups, while other functions showed multiple variations.

Research Question 2: Do teachers' ratings of students' executive functions differ significantly among groups of students whose academic competence is judged to be above average, average, and below average?

MANOVA results indicated that EFs differ significantly among groups of students whose academic competence is judged to be above average, average, and below average. The overall pattern that consistently emerged here was that teachers' ratings of all EFs were in the EF strength range for students rated as having above-average academic competence and in the EF deficit range for students rated as having below-average academic competence. Students rated as having average academic competence were rated as having a varied profile, with some EF raw score means in the EF strength range and some in the EF deficit range.

Research Question 2a: Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence vary depending on the executive function being rated?

Data analyses indicated that there were significant differences in the teachers' ratings of all seven EF clusters when academic competence was taken into consideration as a grouping variable. Post hoc comparisons confirmed that for all clusters, students with above-average academic competence had significantly higher EF raw scores than average students, and average students had significantly higher EF raw scores than below-average students.

For all seven EF clusters, students who were judged as Below Average were rated with item scores associated with an EF deficit, and students judged as Above Average in academic competence were all rated with scores associated with EF strength. While mean scores for

Attention, Engagement, Optimization, and Memory were in the EF strength range for the students judged as Average in academic competence, the mean scores for this group were in the EF deficit range for the Efficiency, Inquiry, and Solution Clusters.

Research Question 2b: Does the relationship between teachers' ratings of executive functions and teacher judgments of academic competence vary depending on the specific executive function being rated?

The findings also showed that no matter the specific self-regulation EF being rated, students rated as having Above-Average academic competence had significantly higher ratings of EF as a group than those students with Average ratings of academic competence. For all 31 EFs, the Below-Average group means were in the EF deficit range, whereas the group means of the students judged as Above Average in academic competence were in the EF strength range.

Mean scores for the Average academic competence group were in the EF strength range for all of the self-regulation EFs within the Attention, Engagement, and Memory Clusters. Mean scores were in the EF deficit range for all of the self-regulation EFs within the Inquiry and Solution Clusters. Mean scores varied within the Optimization and Efficiency Clusters. Within the Optimization Cluster, the mean item score for Modulate was in the EF strength range, while the mean item scores for Monitor, Correct, and Balance dropped just slightly into the EF deficit range. For the Efficiency Cluster, the mean scores for the Sequence and Routines functions were in the EF strength range, while the mean scores for the Sense Time and Pace EFs were in the EF deficit range.

3. Does the relationship between teachers' ratings of executive functions and teachers' judgments of academic competence change based on student age?

No matter the age of the student, a consistent relationship emerged between teachers' judgments of academic competence and mean ratings of EFs. The Above-Average academic competence group consistently earned the highest group mean scores, and these mean scores were consistently within the EF strength range across all ages. Likewise, the Below-Average academic competence group consistently earned the lowest group mean scores, and these mean scores were consistently within the EF deficit range across all ages. The Average academic competence group consistently earned mean scores that were statistically significantly higher than the mean scores of the Below-Average group and significantly lower than the mean scores of the Above-Average group for all ages. Therefore, the relationship between teachers' ratings of EF and teachers' judgments of academic competency does not change based on age.

Summary

The results of this study are consistent with the current body of research that demonstrates that EFs are strongly related to academic competency. Research has shown that EFs not only facilitate learning (Borkowski & Muthukrishna, 1992; Hartman, 2001; Levine, 1999), but also are critical for the effective application of the reading, writing, and calculating skills needed to be a successful student (Berninger & Richards, 2010; Kaufman, 2010; McCloskey et al., 2009). The present study provided evidence that students regarded as possessing above-average academic competence are also viewed as more likely to be using EFs without prompting from a teacher. Students judged as having below-average academic competence were viewed as likely to exhibit EF deficits in that they use EFs only when prompted (deficit).

As a group, students judged as having average academic competence were judged as more capable with some EFs than others, showing a mixed profile of EF strengths and deficits.

As a group, students of average academic competence were rated as having executive strengths for the Attention, Engagement, and Memory Clusters and for the specific Optimization self-regulation EF of Modulate, and the specific Efficiency self-regulation EFs of Sequence and Routine. As a group, students of average academic competence showed slight deficits for the Inquiry and Solution Clusters and the specific Optimization self-regulation EFs of Monitor, Correct, and Balance, and the Efficiency self-regulation EFs of Sense Time and Pace. Thus, the executive profiles for students judged as average in academic competence are more nuanced than the profiles of their above-average and below-average academic competence counterparts.

The results are also consistent with the literature on the relationship between age and EFs. According to research, increases in EF development are large in the younger years and smaller throughout adolescence and adulthood (Bayliss et al., 2005; Lenroot & Geidd, 2006). In general, a significant increase in EF ratings was frequently observed from the 5- to 6-year age group to the 7- to 8-year age group. This finding is consistent with research that found a large increase in problem solving, planning, and fluency during the age range of 5 to 8 years (Anderson, 2002). However, the present study did not show any significant increase in teachers' ratings of inhibition, as previous research has demonstrated across the 5- to 8-year age range.

The data in the present study show that while EF ratings typically increase significantly from age group to age group, this increase is not the case for all of the clusters or specific functions across each age group. In some cases, no increase was observed, and in other cases, a decrease in ratings of some types of EFs actually was observed from younger to older age groups. The majority of the clusters showed an increase for each EF score across all age groups, although not always statistically significant. However, those in the 7- to 8-year age group had a slightly higher, although nonsignificant, mean raw score for Attention than that of their 9- to 10- and 11-

to 13-year-old counterparts. In addition, although nonsignificant, 7- to 8-year-olds had better Engagement scores than those of their 9- to 10-, 11- to 13-, and 14- to 18-year-old counterparts. Thus, while the general trend is EF improvement from youngest to oldest age groups, depending on the specific function or cluster, every EF does not change uniformly across the age span.

While research in human development leads one not to expect increases across all age levels for all functions (Bayliss et al., 2005; Lenroot & Geidd, 2006), another explanation is possible, at least for the nearly uniform drop in EF scores at the 11- to 13-year age group and rebound in the 14- to 18-year age group. This harsher rating happens to coincide with middle-school years, during which teachers abruptly begin to scaffold less, spend less time with students, and expect more independent production compared to during late elementary-school years. Since middle school is a time when expectations for the use of EFs increase substantially and rather suddenly, a decrease in teacher ratings of the effective use of EFs is not surprising.

In terms of a relationship between age and academic competence and EF, no significant interaction was found. Prior to analyzing the data, this author thought that for certain functions, some age groups would not show such a clear distribution of students' EF ratings across competency level. This alternative would mean that at certain ages, teachers do not view certain EFs as having such a powerful relationship to academic competency. The data, however, suggest otherwise. Based on teachers' ratings, all of the EFs tend to be important for academic success across all age groups. With the exception of two EF clusters, the EF ratings across each ability level for all ages seemed to increase significantly. This pattern was broken only in the youngest (5 6 years) age groups between average and above-average students for the Optimization and Engagement clusters. While EF scores did not distinguish above-average students from average students for these clusters in the 5- to 6-year age group, below-average students in this age range did receive lower EF ratings.

Implications of the Findings

In terms of the construct of EFs, while specific EFs did seem to vary, especially by age, they all seemed to follow a general trend. This trend could lead one to interpret EFs as unitary or of a domain-nonspecific construct. This conclusion is easy to make because each cluster and function behaves similarly when grouped by student competence, student age, and a cross of competence and age, with few exceptions. However, the sample data in the study did not demonstrate homogeneity of variance, which suggests that individual subjects' EF scores were more spread out than the group means suggest. While the variability of the sample would lead one to believe that the sample was inherently flawed, the care taken into sampling a group consistent with U.S. Census demographics suggests that teacher ratings of a stratified national sample of students vary widely regardless of age or academic competence. The fact that the data come from a diverse sample and are not homogenous lends support to the ideas that EFs are domain specific and actually vary more on an individual level than this study suggests.

Nonetheless, the findings of this study lend support to the hypothesis that academic ability is strongly associated with EFs. While other innate qualities, such as IQ, are often used as the greatest predictors of student achievement, the findings of this study support the notion that measures of EFs should be used more frequently when making assumptions about students' potentials for achievement. School psychologists may consider using measures of EFs regularly for psychoeducational assessments. The push to promote the teaching of EF skills instead of penalizing students for EF deficits is further supported by the data. The variability of the sample suggests that EFs vary significantly among same-aged students. This variability is important because, despite this fact, teachers' judgments of students' academic competency are highly consistent with their judgments of EF competency.

Rather than penalizing students for low achievement as a result of executive or production deficits, schools could promote better assessment and intervention. Ideally, schools could implement a multitiered model of EF intervention (examples of those already in use), as well as school-wide and targeted community education regarding trends in EF development. Such an approach would discourage penalizing students with poor EF and promote the implementation of EF interventions. Since the research indicates that EFs can be taught and improved upon (e.g., Case & Harris, 1992; Marlowe 2002; Meichanbaum & Goodman, 1971; Reid & Borkowski, 1987), schools could use measures of EF, such as the MEFS, to measure and monitor students' EFs and implement a variety of evidence-based interventions to improve students' EFs.

The data showed that regardless of the student's age, teachers' ratings of EFs still related strongly to teachers' judgments of academic competency. This relationship may not have been expected for elementary-aged students because teachers scaffold and cue students more at younger ages than at older ages. While this fact may be true, students whose EFs were rated higher than those of others also were judged to have higher academic competence across all age groups, young and old. One might theorize that the addition of higher stakes in elementary schools may be causing increased school failure for students with poorer EFs and, therefore, a perception that they possess below-average academic competence. However, the idea that higher standards are developmentally inappropriate for younger students may not hold up. This idea is supported by the fact that the younger students in the above-average academic competency group in this study actually were rated higher for EF than below-average older students. This finding also suggests that the development and effective use of EFs may not be as bound to age as one might think.

The data support the idea that the various EFs and clusters do not improve uniformly across age. Given the importance of EFs in regard to academic competence, schools could utilize information on age ranges where specific EFs are not growing significantly to tailor function or cluster-specific interventions for grade-level-specific EF instruction. This study suggests that the functions of Focus, Initiate, Effort, Inhibit, Stop, Pause, and Shift are good candidates for this type of instruction.

The study also shed light on the overall executive profile of students judged as having average academic competence. By analyzing functions that were found to be areas of deficit even for students judged as average, school-wide EF initiatives could be set. Specifically, the functions within the Inquiry and Solution clusters, as well as the specific functions of Monitor, Correct, Balance, Sense Time, and Pace, are also good candidates for EF instruction. These functions involve the use of looking into the future and generating solutions to problems, creating and implementing realistic plans to do so, and being able to make adjustments to those plans.

Limitations of Study

As mentioned in the previous section, the data did not demonstrate homogeneity of variance. While MANOVA analyses do allow for interpretation of results even when this assumption cannot be supported, the data should still be interpreted with a great deal of caution, as previously noted. Cautiously interpreted, the statistical analyses conducted are useful for showing overall trends for EFs based on age and academic competence, but they may not be indicative of how EFs behave on an individual level. While clear patterns could be discerned from the data, the means reported in this study likely mask the great variability within the sample.

Another limitation is that the study's use of the construct "academic competence" was not based on any objective measures, such as grades, standardized assessment test scores, or achievement tests. Rather, the competence variables were drawn from a single assessment question, which greatly constrains the utility and validity of the academic competency construct as operationally defined for this study. Despite this limitation, the ratings provided were interesting in their own right because students are impacted by the subjective opinions of their teachers on a daily basis.

Confounding variables, such as teacher's age, years of teaching experience, and years of training, that may influence teachers' judgments were not accounted for in this study. Thus, although the construct of academic competence is interesting, the validity of the teachers' ratings is limited because of variability in unaccounted characteristics of each teacher. Further, innate psychological phenomena, such as varying severity or leniency (Linacre, 1989), may impact the consistency of teachers' ratings of students' use of EFs.

Additionally, research shows that raters may rate their students by qualities other than those the questions had intended. A halo effect (Nisbett & Wilson, 1977) may result from teacher bias, including varying teacher interpretations of the scale's items and varied perceptions of the students whom they rated. They may rate all attributes higher for students whom they view more favorably and may not apply this bias to students for whom they have less preference. This phenomenon could have resulted in high EF ratings for high-achieving students even though they actually may have had poor EFs. Alternatively, teachers could have rated students as more competent because of a factor, such as liking the student more than their counterparts.

Confounding student factors, such as gender or ethnicity, also may have impacted the results of this study. For instance, students from an ethnic group more associated with a lower socioeconomic status may receive lower ratings on both academic competence and EF. Although data regarding the other demographic characteristics of the students in the sample, such as ethnic group membership and gender, were reported, the possible effects of these other demographic variables were not empirically tested as part of this study.

Future Directions

Since this investigation was one of the first to study the MEFS, it would be interesting to see if such factors as gender or cultural difference would have resulted in greater variation between clusters and functions. Based on the findings of this study, large groups of students do not necessarily have homogenous EFs. An examination of the differences within a variety of groups would be useful in more effectively contextualizing studies that examine differences between groups.

Since the MEFS is a new measure of EF, more studies are needed to investigate the predictive, convergent, and content validity of the scale. A worthwhile study would be to determine how the scale deviates from counterparts, such as the Behavior Rating Inventory of Executive Function (Gioia et al., 2000) or the Comprehensive Executive Function Inventory (Naglieri & Goldstein, 2013).

Finally, future studies should observe the effects of an intervention on teachers' ratings of EF and academic competency. This study highlighted the manner in which teachers view student academic competency in relation to their use of EFs. It would be valuable to know if effective EF interventions could be utilized to improve students' EF and, if so, if a teacher's perception of their academic competency also would increase.

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Appendices

Appendix A. MEFS Rating Scale- Teacher Form

BECOMING AWARE						
Knows what he or she should be doing for school tasks and knows when to do it.	AA	F	S	AP	DA	UA
Makes eye contact with, listens to, and touches others in an appropriate way in social situations.	AA	F	S	AP	DA	UA
Is aware of own feelings thoughts and actions. (Says things that reflect an awareness of feelings they may be experiencing, thoughts they may be having, or things they are doing.)	AA	F	S	AP	DA	UA
FOCUSING ATTENTION						
Focuses attention on school tasks.	AA	F	S	AP	DA	UA
Focuses attention on others in social situations.	AA	F	S	AP	DA	UA
Focuses attention on own actions.	AA	F	S	AP	DA	UA
SUSTAINING ATTENTION						
Sustains attention for school tasks until a task is completed.	AA	F	S	AP	DA	UA
Sustains attention to others in social situations.	AA	F	S	AP	DA	UA
Sustains attention to own actions.	AA	F	S	AP	DA	UA
INITIATING						
Starts school work.	AA	F	S	AP	DA	UA
Initiates socially appropriate interactions with other students.	AA	F	S	AP	DA	UA
Does self-care tasks.	AA	F	S	AP	DA	UA
GETTING ENERGIZED FOR / PUTTING EFFORT INTO						
Puts adequate energy into, school tasks.	AA	F	S	AP	DA	UA

Puts adequate energy into, interacting with others.	AA	F	S	AP	DA	UA
Puts adequate energy into, taking care of self.	AA	F	S	AP	DA	UA
INHIBITING						
Waits for turn.	AA	F	S	AP	DA	UA
Considers the consequences before saying or doing things he or she may regret.	AA	F	S	AP	DA	UA
Refrains from acts of physical aggression.	AA	F	S	AP	DA	UA
Does not make inappropriate or thoughtless comments (for example, name-calling, insulting, inappropriately tattling on others).	AA	F	S	AP	DA	UA
Controls emotional reactions well in frustrating situations.	AA	F	S	AP	DA	UA
Maintains emotional control when doing challenging school work.	AA	F	S	AP	DA	UA
Maintains emotional control when disagreeing with others.	AA	F	S	AP	DA	UA
STOPPING						
Knows when to stop talking about a single topic.	AA	F	S	AP	DA	UA
Stops playing a game or stops doing something that is fun when asked to do so.	AA	F	S	AP	DA	UA
Stops doing things that annoy others when asked to do so.	AA	F	S	AP	DA	UA
Stops doing harmful or bothersome things to self (picking at skin, biting nails, etc) when asked to do so.	AA	F	S	AP	DA	UA
Stops negatively feeling or thinking the same way about himself or herself.	AA	F	S	AP	DA	UA
PAUSE & CONTINUE						
Returns to a school task after a brief pause.	AA	F	S	AP	DA	UA
Pauses to listen to what another person has to say during conversations.	AA	F	S	AP	DA	UA
Returns to what they were thinking about or doing after a brief pause.	AA	F	S	AP	DA	UA
FLEXIBLY ENGAGING						
Willing to try a different way to do school tasks when he or she gets stuck.	AA	F	S	AP	DA	UA
Accepts a good idea when it is what most others in a group want to do.	AA	F	S	AP	DA	UA
Accepts the need to think about or feel differently about himself or herself when	AA	F	S	AP	DA	UA

the way he or she is thinking or feeling is not working out well.						
Accepts changes in school work or school routines without getting upset about it.	AA	F	S	AP	DA	UA
Accepts changes in a person he or she knows or to accept unfamiliar persons without getting upset.	AA	F	S	AP	DA	UA
Accepts when it is necessary to change personal habits because they are causing difficulties.	AA	F	S	AP	DA	UA
SHIFTING						
Moves from one school task to another without difficulty.	AA	F	S	AP	DA	UA
Changes from one activity to another in social situations without difficulty.	AA	F	S	AP	DA	UA
Changes personal habits when they are causing problems.	AA	F	S	AP	DA	UA
MODULATING OR ADJUSTING						
Physical activity level fits the situation when doing school tasks (Not hyperactive or inactive).	AA	F	S	AP	DA	UA
Physical activity level fits the situation when working in a group (Not hyperactive or inactive).	AA	F	S	AP	DA	UA
Adjusts physical activity level when working alone so as not to be hyperactive or inactive.	AA	F	S	AP	DA	UA
Emotional response fits the situation when working on school tasks (Doesn't overreact or underact).	AA	F	S	AP	DA	UA
Emotional response fits the situation when interacting with others (Doesn't overreact or underreact).	AA	F	S	AP	DA	UA
Avoids being overstimulated or understimulated by sights, sounds, or touches.	AA	F	S	AP	DA	UA
MONITORING						
Checks school work to avoid careless errors on tests and other school work.	AA	F	S	AP	DA	UA
Recognizes situations in which his or her behavior bothers or upsets others.	AA	F	S	AP	DA	UA
Checks to make sure that he or she has everything they need before leaving class or school.	AA	F	S	AP	DA	UA

Checks on his or her appearance, cleanliness and personal hygiene.	AA	F	S	AP	DA	UA
CORRECTING						
Corrects errors that are made in school work.	AA	F	S	AP	DA	UA
Apologizes when aware of offending others.	AA	F	S	AP	DA	UA
Changes his or her opinions about self or others that were caused by misperceptions about himself or herself or another person.	AA	F	S	AP	DA	UA
BALANCING						
Balances the elements of a school assignment (speed vs accuracy, quality vs quantity; general vs specific statements; depth vs breadth, etc.).	AA	F	S	AP	DA	UA
Maintains a balance in social situations (talking vs listening, sharing too much vs sharing too little; being humorous vs being serious).	AA	F	S	AP	DA	UA
Maintains a balance in his or her own activities (play vs work; time alone vs time with others; sleep vs awake).	AA	F	S	AP	DA	UA
GAUGING or "SIZING UP"						
Accurately estimates the difficulty of school tasks and/or tests and what it takes to complete them and/or do well with them.	AA	F	S	AP	DA	UA
Figures out how to interact appropriately in various social situations.	AA	F	S	AP	DA	UA
Figures out what it takes to maintain self-control in difficult situations.	AA	F	S	AP	DA	UA
ANTICIPATING						
Anticipates events at school. (for example, recognizes the need to prepare for tests or assignments; connects homework with grades, etc.).	AA	F	S	AP	DA	UA
Anticipates how what he or she says or does will affect how others feel, think or act.	AA	F	S	AP	DA	UA
Anticipates the consequences of his or her own thoughts, feeling and actions. (for example, recognizes that if he or she doesn't do a chore he or she won't be able to play with a friend and will feel disappointed about it).	AA	F	S	AP	DA	UA
ESTIMATING TIME						
Accurately estimates how long it will take to do something when involved with one or more school tasks.	AA	F	S	AP	DA	UA

Accurately estimates how long it will take to do something when talking to others or doing things with others.	AA	F	S	AP	DA	UA
Accurately estimates how long it will take to do something when doing things alone.	AA	F	S	AP	DA	UA
ANALYZING SITUATIONS						
Examines and analyzes things in more detail when doing school tasks.	AA	F	S	AP	DA	UA
Examines and analyzes in more detail what others are saying or doing in social situations.	AA	F	S	AP	DA	UA
Examines and analyzes in more detail thoughts and feelings he or she has about himself or herself or things he or she does alone.	AA	F	S	AP	DA	UA
EVALUATING / COMPARING						
Evaluates the quality and/or adequacy of his or her work on school tasks.	AA	F	S	AP	DA	UA
Evaluates the quality and/or adequacy of his or her social interactions.	AA	F	S	AP	DA	UA
Evaluates the quality and/or adequacy of his or her thoughts and feelings about himself or herself or about the things done when alone.	AA	F	S	AP	DA	UA
GENERATING SOLUTIONS						
Comes up with new ways to solve problems with school tasks.	AA	F	S	AP	DA	UA
Come up with new ideas about things to say to, or do with, others.	AA	F	S	AP	DA	UA
Comes up with new ways of thinking or feeling about himself or herself or new ways of doing things for himself or herself.	AA	F	S	AP	DA	UA
MAKING ASSOCIATIONS						
Sees or understands how two or more things or ideas are similar and can use that knowledge to solve a problem with school work.	AA	F	S	AP	DA	UA
Sees or understands how one social situation can be similar to another and can use that knowledge to solve a social relationship problem.	AA	F	S	AP	DA	UA
Sees or understands how two or more things he or she has done, or ideas he or she has had, are similar and can use that knowledge to solve a personal problem.	AA	F	S	AP	DA	UA
ORGANIZING						

Organizes school tasks.	AA	F	S	AP	DA	UA
Organizes age appropriate social activities.	AA	F	S	AP	DA	UA
Organizes his or her own thoughts and feelings.	AA	F	S	AP	DA	UA
PLANNING						
Makes plans for school tasks.	AA	F	S	AP	DA	UA
Makes plans for age appropriate social activities.	AA	F	S	AP	DA	UA
Makes plans for the use of his or her own time.	AA	F	S	AP	DA	UA
PRIORITIZING						
Orders school tasks according to their relevance, importance, or urgency.	AA	F	S	AP	DA	UA
Handles social activities according to their relevance, importance or urgency.	AA	F	S	AP	DA	UA
Orders own thoughts and feelings or personal activities according to their relevance, importance or urgency.	AA	F	S	AP	DA	UA
DECISION-MAKING						
Makes own decisions about what to do for school and/or when to do it.	AA	F	S	AP	DA	UA
Makes own decisions about what to do with others and/or when to do it.	AA	F	S	AP	DA	UA
Makes own decisions about what to do and when to do it when alone.	AA	F	S	AP	DA	UA
SENSING TIME						
Keeps track of time (e.g., realizes how much time has passed) when doing school tasks.	AA	F	S	AP	DA	UA
Keeps track of time (e.g., realizes how much time has passed) when talking to or doing things with others.	AA	F	S	AP	DA	UA
Keeps track of time (e.g., realizes how much time has passed) when working independently.	AA	F	S	AP	DA	UA
PACING						
Changes pace (works slower or works faster) when taking tests or doing school assignments.	AA	F	S	AP	DA	UA

Changes pace in social situations (for example, talks slower or talks faster to maintain the pace of the conversation).	AA	F	S	AP	DA	UA
Changes pace (goes slower or faster) when working independently.	AA	F	S	AP	DA	UA
USING ROUTINES/COMPLETING ASSIGNMENTS (EXECUTING)						
Uses well-rehearsed or practiced routines for school tasks (for example, recognizing words by sight, printing or writing letters and words, reciting basic math facts).	AA	F	S	AP	DA	UA
Uses well-rehearsed or practiced social greetings or conversation starters.	AA	F	S	AP	DA	UA
Uses well-rehearsed or practiced routines for hygiene and self-care.	AA	F	S	AP	DA	UA
Generate good ideas and gets them down on paper quickly and efficiently.	AA	F	S	AP	DA	UA
Uses routines and strategies to do well on tests.	AA	F	S	AP	DA	UA
Uses routines and strategies to get assignments and projects done.	AA	F	S	AP	DA	UA
Participates in discussions about topics that he or she knows a lot about.	AA	F	S	AP	DA	UA
Brings home all the materials need to complete homework and other school tasks.	AA	F	S	AP	DA	UA
Hands in homework, assignments or important papers when they are completed.	AA	F	S	AP	DA	UA
SEQUENCING						
Gets the steps in the right order when working on school tasks.	AA	F	S	AP	DA	UA
Gets the order of events right when telling stories or explaining things to others.	AA	F	S	AP	DA	UA
Gets the steps in the right order when performing personal care tasks.	AA	F	S	AP	DA	UA
HOLDING and WORKING WITH INFORMATION IN MIND						
Can briefly remember and work with information in mind when doing school tasks. (For example, can add 3 or more numbers without pencil and paper; can remember directions that were just given by the teacher.)	AA	F	S	AP	DA	UA
Can briefly remember and work with information in mind when talking with others. (For example, can follow and participate in a longer conversation.)	AA	F	S	AP	DA	UA
Can briefly remember and work with information in mind when doing things alone. (For example can write an essay or remember a story that was just read.)	AA	F	S	AP	DA	UA
STORING and RETRIEVING						

Stores and recalls specific information about school subjects no matter how questions are worded.	AA	F	S	AP	DA	UA
Stores and recalls specific information about others or about social situations.	AA	F	S	AP	DA	UA
Stores and recalls specific information about himself or herself.	AA	F	S	AP	DA	UA
Does well on tests that require recall of stored facts no matter what test format is used.	AA	F	S	AP	DA	UA
Does well in social situations that require recall of facts about others.	AA	F	S	AP	DA	UA
Does well in situations that require recall of facts about himself or herself.	AA	F	S	AP	DA	UA

INSTRUCTIONS

For each statement below, think about the student and circle the option that best describes this student:

N/R Never or rarely does this.

S Does this sometimes, but not much

O Does this often

VO Does this very often

When responding to statements, keep in mind that children and adolescents vary naturally based on age. For example, six year olds are typically less capable than 10 year olds, while 10 year-olds are typically less capable than 18 year olds. When rating this student, think about this student in relation to what you think would be typical of other children of similar age, rather than of siblings who are older or younger, other children you know who are not the same age, or children in general.

SELF-REALIZATION: AWARENESS OF SELF				
Makes realistic comments about his or her own mental and emotional strengths and weaknesses.	N/R	S	O	VO
Makes realistic comments about his or her own physical abilities.	N/R	S	O	VO
Makes realistic comments about what he or she feels or thinks about himself or herself.	N/R	S	O	VO

SELF-REALIZATION: AWARENESS OF OTHERS				
Makes realistic comments about the mental and emotional strengths and weaknesses of others.	N/R	S	O	VO
Makes realistic comments about the physical abilities of others.	N/R	S	O	VO

Makes realistic comments about what he or she thinks other people feel or think about others.	N/R	S	O	VO
Makes realistic comments about what he or she thinks others feel or think about him or her.	N/R	S	O	VO
Makes realistic comments about what he or she thinks other people feel or think about themselves.	N/R	S	O	VO
SELF-REALIZATION: ANALYSIS OF SELF AND OTHERS				
Realistically analyzes and comments about his or her school performance.	N/R	S	O	VO
Realistically analyzes and comments about his or her ability to know what others appear to think or feel about him or her.	N/R	S	O	VO
Realistically analyzes and comments about his or her ability to manage himself or herself.	N/R	S	O	VO
SELF-DETERMINATION: GOAL-SETTING				
States realistic goals for schooling based on personal interests.	N/R	S	O	VO
States realistic goals for work beyond school based on personal interests.	N/R	S	O	VO
Expresses strong desires to make his or her own decisions about what to do rather than be told what to do by parents or others.	N/R	S	O	VO
SELF-DETERMINATION: LONG-TERM PLANNING				
States realistic plans for accomplishing long-term schooling goals.	N/R	S	O	VO
States realistic plans for accomplishing long-term work goals.	N/R	S	O	VO
States realistic plans for accomplishing social and/or personal goals.	N/R	S	O	VO
SELF-GENERATION				
Asks questions about the meaning or purpose of life.	N/R	S	O	VO
Asks questions about the purpose or meaning of school.	N/R	S	O	VO
Asks questions about why we exist.	N/R	S	O	VO
Asks questions about what happens to us when we die.	N/R	S	O	VO
Wants to know why things are considered right or wrong.	N/R	S	O	VO
Asks questions about the right way to treat other people.	N/R	S	O	VO

Appendix B. MEFS-TR Item Rating Rubric

5	AA	Always or almost always does this on his or her own. Does not need to be prompted or reminded (cued) to do it.
4	F	Frequently does this on own without prompting
3	S	Seldom does this on own without being prompted, reminded, or cued to do so.
2	AP	Does this only after being prompted, reminded, or cued to do it.
1	DA	Only does it with direct assistance. Requires much more than a simple prompt or cue to be able to get it done in situations that require it.
0	UA	Unable to do this, even when direct assistance is provided.

Appendix C. MEFS Inconsistency Scale

Item #	Pair	Item Wording
5	Pair 1	Sustains attention for school tasks until a task is completed.
40	Pair 1	Pays attention as long as needed to complete school tasks.
6	Pair 2	Sustains attention to others in social situations.
41	Pair 2	Pays attention as long as needed when talking or interacting with others.
7	Pair 3	Starts school work.
66	Pair 3	Gets started on school work.
8	Pair 4	Initiates socially appropriate interactions with other students.
67	Pair 4	Initiates socially appropriate interactions with others.
23	Pair 5	Willing to try a different way of doing school tasks when he or she gets stuck.
92	Pair 5	Accepts the need to try a different way to do school tasks when he or she gets stuck.
24	Pair 6	Accepts a good idea when it is what most others in a group want to do.
93	Pair 6	Can go along with a good idea when it is what others in a group want to do.